STUDIES ON TRANSPLANTING OF IRRIGATED COTTON

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CERTIFICATE

This is to certify that the thesis entitled "STUDIES ON TRANSPLANTING OF IRRIGATED COTTON" submitted in part fulfilment of the requirements for the award of the degree of DOCTOR OF PHILOSOPHY IN AGRONOMY to the Tamil Nadu Agricultural University, Coimbatore, is a record of **bona fide** research work carried out by Mr N. GOPALASWAMY under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles and that the work has not been published in part or full in any scientific or popular journal or magazine.

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Abstract

ABSTRACT

STUDIES ON TRANSPLANTING OF IRRIGATED COTTON

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The scope of transplanting cotton under irrigated conditions was field tested during 1979 to 1981 with two cultivars (MCU 9 and Varalakshmi), two methods of raising nursery (Pai nursery and polythene bag) and three ages of seedling (20, 40 and 60 days) compared with the direct seeding during the normal sowing period (14th August) in a randomised blocks design, replicated thrice during 1979. In the next year, two ages of seedlings (30 and 45 days) and the direct seeding were compared at three levels of N (90, 120 and 150 kg N/ha) under three dates of sowing (14th August, 29th August and 13th September). In 1981, three ages (20, 30 and 45 days) and the direct seeding were studied at two population levels (17,860 and 22,222 plants/ha) under the three dates of sowing in a split plot design, replicated thrice.

The hybrid, Varalakshmi yielded better than MCU 9 both under direct sown and transplanted conditions. Seedlings raised from pai nursery and polythene bags did not differ in their yield potential. Owing to cheapness, ease of raising and maintenance, pai nursery offered greater scope for large scale adoption. The extent of establishment of seedlings in the main field was 92-98 as against 86-92 per cent with the direct seeding.

The crops sown and transplanted on 14th August were superior in growth and yield components owing to prevalence of optimum weather conditions. Progressive reduction in seed cotton yield was observed with a successive fortnightly shift in sowing and transplanting from 14th August to 13th September. The solar radiation levels received during the cropping period accounted for 74 per cent of variations in the seed cotton yield.

The boll maturation and harvesting periods were shortened by 10-15 days in the late sown crops due to an increase in relative temperature disparity (RTD) from October to March. Progressive decrease in the accumulated photothermal units (PTU) and solar radiation levels (SR) were observed as the sowings and transplantings were delayed. It was predicted that an accumulated PTU of 27,000 (2500 growing degree days and a quantum of 40,000 Cal cm^{-2} (222 Cal cm^{-2} day^{-1}) of SR would be required to produce 30 q/ha of seed cotton. The solar energy conversion efficiency was greater in 14th August sown and transplanted crops. The net return was high in the 14th August crops.

Application of N at 120 kg/ha was economical for the 14th August sowing and 90 kg N/ha for late sown crops. Nitrogen application promoted the solar energy conversion efficiency and P and K uptake.

The higher population increased the seed cotton yield with 29th August and 13th September crops, whereas, for the 14th August crops, the population levels were of no consequence.

The transplanted crops were shorter with lesser LAI and DMP than the direct seeded ones due to lag period observed during the establishment stage coupled with an early shift to the reproductive phase.

In 1979, the 20 day old seedling was superior in seed cotton yield over the 40 and 60 day old seedlings and produced as much as 97 per cent of the direct sown crops. During 1980 and '81 the 30 day old seedling was superior in seed cotton yield to the direct sowing and the 45 day old seedling, coupled with a reduction in field duration by two weeks. The mean increase in seed cotton yield registered by the 30 day old seedling was 4.80, 6.68, 5.34 q/ha, respectively, over the direct seeding under 14th August, 29th August and 13th September. In both the years, the seed cotton yield from the 30 day old seedling transplanted on 29th August was comparable with that of the direct seeded crops sown on 14th August. Likewise, transplanting the 30 day old seedling on 13th September resulted in an increased yield by 2.64 q/ha than the 29th August direct sown crops. The net return and return per rupee invested was high with the 30 day old seedling.

The results of the present study have brought out the advantage of the transplanting over the conventional direct sowing, especially under late sown conditions. Raising the pai nursery in advance and transplanting 30 days old seedling early in the season would result in yield advantage over the direct seeding. In case of anticipated delay in the availability of the mainfield and water receipt for irrigation, transplanting proves more beneficial to the late direct seeding. In water scarcity areas, nurseries can be raised at required intervals and seedlings transplanted in a phased manner. Thus, transplanting in cotton proves to be a viable agronomic practice to make good the probable yield loss of late seeding.

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CHAPTER I

INTRODUCTION

India has the unique distinction of growing cotton in a largest area of 8.1 million hectares amongst the cotton growing countries of the world, accounting for about 10 per cent of the total area under this crop. It ranks 4th in production, next to USSR, China and USA with an average yield of 176 kg of lint/ha. In Tamil Nadu, it is grown in 328 thousand hectares, out of which 48 per cent is under irrigation. In production, it ranks 3rd (496 thousand bales) with a mean yield of 257 kg of lint/ha.

Cotton is a long season plant, requiring uniformly high temperature during the growing season and also adequate sunshine hours during the period of early growth to full bloom. The specific climatic requirement of the crop limits its cultivation to warmer regions. It is very sensitive to the changes in climatic conditions. Hence, the optimum sowing period should provide the weather requirements of the crop at the required level. The optimum time has been found to vary within the sowing season of a place. Delayed sowings invariably result in reduced yields. The delay in sowing under certain situations becomes unavoidable due to scarcity of water for irrigation. Under such contingencies, in the case of other crops, nurseries are raised at the optimum periods and seedlings transplanted later. Such technologies are not practised in cotton.

Attempts were made to transplant cotton by raising nurseries as practised in cereal crops. Yield levels were far from satisfactory owing to poor establishment as compared to the direct seeded crops. Seedlings were also raised in polythene bags and transplanted. Though the yield level was comparable with direct sowing, the cost in raising seedlings is too high for adoption under large scale. Of late, similar to _dapog_ nursery in rice, _pai_ nurseries were developed in Tamil Nadu with a high per cent of success in the establishment of seedlings. The information on the optimum age of seedlings, comparative performance with direct sown crops under different dates in a season and other agronomic practices available are meagre.

The present investigation was therefore taken up to

i) evaluate the different methods of raising seedlings

ii) fix the optimum age of seedlings for transplanting

iii) compare the performance of transplanted crops with direct seeding under different dates in the winter season

iv) study the response of transplanted crop to nitrogen and population levels

v) study the seasonal influence on growth and yield of cotton.

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Cotton is an important commercial crop grown in winter as well as in summer under irrigated conditions. Cotton is very specific to its climatic requirements and reacts unfavourably for any shift in sowing date from the normal period. Experiments have conclusively proved that late sowing in a locality invariably results in reduced yield. However, practically it becomes difficult to stick to optimum time of sowing. Late harvest of previous crop, unfavourable soil condition for the preparation of land owing to inclement weather, non-availability of water for irrigation, uncertainty in receipt of water in canals are some of the causes which lead to delayed sowing. Under such situations, to minimise the magnitude of yield losses due to delayed sowings, agronomic practices such as adoption of closer spacing, dibbling the seeds with minimal tillage in stubbles of the previous crops are advocated. The results of the recent investigations with transplanting of cotton through seedlings raised at the optimum period in advance offer scope for mitigating the ill- effects of late sowing.

Relevant literature on

i) Nursery techniques and transplanting in cotton.

ii) Effect of sowing dates and weather parameters on growth, yield components, yield and quality characters.

iii) Effect of nitrogen on growth, yield components, yield and quality characters.

iv) Effect of plant population on growth, yield components, yield and quality characters.

v) Studies on nutrient uptake, which may throw some light on the problem chosen are reviewed in the following pages.

2.1. Nursery techniques and transplanting

2.1.1. Vegetative propagation: Cotton is a tap rooted plant. As such direct seeding is the rule. With the introduction of hybrid cottons for large scale cultivation the cost of seeds has escalated because of the labour intensive hybrid seed production system.

Attempts were therefore made to propagate the plants through cuttings as in other horticultural crops. Hard and semihard wood cuttings from monopodial branches were made to root in the field nurseries by treating them with plant hormones like 2,4-D and planted after 45 days (Sheelavantan et al., 1975). Instead of field nurseries, the cuttings were made to root in polythene bags and this method was found useful in propagating and maintaining the parents used for hybridisation (Paulas, 1979). The possibility of air layering was established by Mehetre and Thombre (1977) in sterile plants. They observed the root formation within 28 - 39 days and complete establishment of layers was observed. The large scale adoption of this method was not feasible because of the sophisticated techniques involved in producing large number of air layers.

2.1.2. Transplanting through seedling: In Maharastra, Kulkarni *et al*. (1961), succeeded in transplanting 22 days old seedlings of CO 4 long staple cotton raised in field nurseries with more than 95 per cent establishment in the main field. At Coimbatore, Palaniappan and Ramaswamy (1974) through their field studies observed a reduction in yield to the tune of 80 per cent when cotton was transplanted with seedlings, raised from field nurseries as compared to that from the direct sown crop. Seedlings raised from specially prepared nurseries in which the top soil was removed to a depth of 15 cm and refilled with pea haulms to a depth of 7.5 cm over laid with soil and compost were tried by Govil and Singh (1977) in Utter Pradesh. They observed, direct seeding to be advantageous over transplanting, however, they recommended the use of seedlings so raised, for gap filling in the direct sown crops.

Investigations by Gaffer *et al*. (1979) in Egypt as well, indicated the superiority of direct seeded crop in its yielding ability over transplanted crop, even under late sown conditions. These observations pointed to the feasibility of transplanting cotton, eventhough, the yield with transplanted crop fell short of direct sown crop.

In Maharastra, Bodade (1965), compared the performance of crop with seedlings raised under different methods against the direct sowing. He observed better establishment with seedling raised in polythene bags and leaf cups in the main field (80%), as compared to direct seeding (72%). Later studies on this aspect revealed that seedlings of 45 day old raised in polythene bags performed better than direct sown crops even under rainfed conditions (Kaiwar, 1972 and Singh and Jain, 1974). In Rajasthan, Mathur et al. (1976), recorded maximum plant stand and increased yields when cotton was transplanted from the seedlings raised in polythene bags. Besides, the transplanted crop endured the high temperature and wind erosion hazards during the normal sowing period in the month of April, most successfully than the direct sown crops. Owing to high cost involved in the production of seedlings in polythene bags, it was recommended for gap filling in the direct sown crops.

The tap root system of cotton is the bottle neck in transplanting. To obviate this difficulty, attempts were made to arrest the tap root growth and to induce the fibrous root system in the seedling stage, by providing an impervious layer below the rooting medium. In Tamil Nadu, for cotton, '*Pai* nursery' was attempted, simulating *Tapog* method of raising rice seedlings. The nursery can be rolled like a mat and taken to the main field at the time of transplanting (Arunachalam and Ramanujam, 1981).

The authors reported, increased yield, reduction in field duration to the tune of 15 - 20 days, avoidance of late sowing, reduction in water use and plant protection.

2.1.3. Standardisation of nursery techniques: Based on the results of the studies conducted at the Cotton and Millet Experiment Station, Koilpatti, the following practices were formulated and recommended for adoption (Arunachalam and Ramanujam, 1981).

Input requirement for producing seedlings to plant one hectare of main field

Input	Variety	Hybrid
Nursery area	25 m^2	12.5 m^2
Polythene sheet	30 m^2	15.0 m^2
Old gunny	30 m^2	15.0 m^2
Farm yard manure and sand mixture at 1:1 ratio	100 kg	60 kg
Seed rate (Acid delinted)	8.75 kg @ 350 gm/m^2	2.0 kg @ 160 gm/m^2
Di-ammonium phosphate	1.250 kg @ 50 gm/m^2	0.625 kg @ 50 gm/m^2

2.1.4. Effect of age of seedling on seed cotton yield: Age of seedling in cotton as in cereals exhibited a negative relationship on seed cotton yield. Studies made by Arunachalam and Ramanujam (1981) indicated that the optimum age of seedling varied with the varieties. The seedlings of MCU 8, transplanted from Pai nursery at 20 days resulted in 28 per cent increased yield over direct seeded crop, while, 45 day old seedling registered only 9 per cent increase. In the case of Varalakshmi, 40 day old seedling gave the maximum seed cotton yield amounting to an increase of 16 per cent over the direct seeded crop. Transplanting of 40 day old seedling of MCU 7 and 35 day old seedling of Varalakshmi in rice fallows, recorded comparable yield of seed cotton with that of their respective direct sown crops (Parthasarathy, 1979).

Studies carried out at the Tamil Nadu Rice Research Institute Aduthurai, indicated that transplanting of 25 day old seedling of MCU 7 and K_2HC obtained from the advance nurseries resulted in an increased seed cotton yield by 3.6 and 2.2 q/ha, respectively, over their direct seeded crops dibbled on the day of transplanting (Arunachalam, 1981). Under rainfed condition, Krishnadoss et al. (1979) observed that transplanting of 40 day old seedling of Varalakshmi, resulted in 11 per cent increase in yield over the direct sown crop.

2.1.5. Effect of age of seedling on field duration: Field duration is of great importance in multiple cropping systems to accomodate more number of crops per unit time. Transplanting facilitates reduction in field duration of the crop, thus, proving to be a viable Agronomic technology for multiple cropping systems. Agronomic investigations indicate a gradual reduction in field duration as the age of seedlings at planting increases. The reduction in the duration was about 20 days when 40 day old seedlingwere planted (Arunachalam and Ramanujam, 1981). A reduction to the tune of 40 days was observed by Parthasarathy (1979) in MCU 7 cotton using 40 day old seedling for transplanting. However, in Varalakshmi the reduction in field duration was only 20 days, when 35 day old seedling was transplanted.

2.2. Effect of sowing dates and weather parameters on growth, yield and quality characters

2.2.1. Effect on growth and yield components: Earlier works done in Egypt, Sudan and elsewhere threw light on the importance of the optimum sowing periods for cotton in maximising the yield and in reducing the crop losses due to pest and diseases and physiological disorders (Gregory et al., 1932, Lambert and Crowther, 1935). The date of sowing of the cotton crop appears to be a very important factor that affects its growth and yield. As a rule, cotton crop meets with slightly different conditions of day length, temperature and humidity during its two main phases viz., vegetative and reproductive phases. The crop should therefore be sown, so that the optimum seasonal conditions coincide with the two phases to exploit the maximum yield potential of a variety (Dastur, 1959).

Many authors from their studies observed that early sowing in the season resulted in optimum vegetative growth and more number of bolls with increased weight which ultimately increased the yield over the late sown crops (Kanniyan and Balasubramanian, 1952; Kalyanaraman and Rangaswamy, 1957; Sharma, 1961; Shekhawat and Chundawat, 1970 and Misra and Malik, 1979).

2.2.2. Optimum period of sowing: Sowing time is automatically adjusted by long practice and experience. It is possible that the best sowing period would vary in different parts of the same tract. No general principle could be laid down for fixing the optimum sowing period as the crop in each tract has to be studied separately on account of different combinations of soil and season. In some tracts the range of sowing period may be wide, while, in others it may be narrow (Dastur, 1959).

The results of the studies conducted at Coimbatore to fix the normal sowing period for winter Cambodia cotton indicated a reduction in yield by 42 per cent when sowing was delayed to October as against September (Anon, 1930).

Kanniyan and Balasubramanian (1952) observed progressive and rapid decline in yield as the sowing was shifted from 5th September to 20th October. The results of recent studies by Chamy and Balasubramanian (1976) broughtout the advantage of advancing the sowings. Early August sowings resulted in higher yields and the first fortnight of August was found to be the optimum period for the variety MCU 5. With regard to summer cotton for Coimbatore, tract sowing by December-January was found not congenial for high yield (Kalyanaraman and Rangaswamy, 1957). Subsequently, Sivakumar (1977) observed that the optimum period for MCU 7 summer cotton was 20th February.

The optimum sowing period for winter Cambodia cotton in the Parambikulam Aliyar Project area was from 15th to 30th September (Gopalaswamy and Elangovan, 1977). Balasubramanian et al. (1979) from their field studies concluded that advancing the sowings of summer cotton in the southern districts of Tamil Nadu to February 15th from March first week resulted in an increased yield. In South Arcot district of Tamil Nadu, early sowings in December-January were advocated instead of March sowing for higher yield due to less centabescent flowers. For the same district, the month of August was found to be the optimum period for winter crop (Ramachandran and Sethuraman, 1955).

In Parbhani (Maharashtra), the normal sowing date was observed as 4th August. Early sowings by 19th April resulted in as much as 211 per cent increased yield over the normal date. When sowing date was shifted to 5th July, the increase was only 20 per cent. In Siruguppa, 15th July sowings increased the yield by 32 per cent over the normal date of 14th August. Advancing the sowings from normal date to 31st July, the increase was 14 per cent. In Raichur the yield increase was 47 per cent, when the sowings were taken up on 1st May, while, the increase was only 17 per cent for the 1st June sowings (Koraddi *et al.*, 1980). In Uttar Pradesh, Sharma (1961) observed, April 1st was the optimum sowing date, while, subsequent findings of Singh *et al.* (1968) and Govil and Singh (1977) revealed that 15th March was better than later sowings. Misra and Malik (1979) under Banaras conditions observed the optimum date of sowing to be 12th May.

In Rajasthan, Simlote *et al.* (1967) concluded that the sowing on April 30th was superior to other delayed sowings. However, later studies by Shekhawat and Chundawat (1970) indicated a reduction in yield when sowings were delayed from 20th April to 19th June. For Nemar tract of Madhya Pradesh, Singh *et al.* (1969) suggested mid-May sowings for increased yield. Dastur (1959) observed that different strains had different optimum periods of sowing in the same locality in Punjab and the optimum period was from late May to June. Subsequently, Singh (1967) suggested that sowings should be completed before May for better yield.

Parry (1961) observed early March to be the optimum sowing time in Sahara regions. Couilloud and Daeschner (1971) from Iran did not find any yield difference, when cotton was sown in February or mid-April. Srisook *et al.* (1973) in Central plains of Thaiwan, observed that December sowings gave higher seed cotton yield. In Bangaladesh, Sobhan (1979) suggested to complete the sowings during the first fortnight of September for higher yield.

The time at which cotton should be planted depends on weather conditions which vary widely from one place to another and also from year to year. In fact, during the whole year there is hardly any date on which planting does not take place in one or another part of the world. The months in which it occurs in most important cotton growing countries are, Tanganyika-January to May; Mexico-February; Egypt-March; Turkey-March to May; U.S.A., China, Russia and Greece-March to June; Uganda-May to August; India-June to August; Sudan-July and August; Australia-September to January; Brazil-September to December and Rhodesia and South Africa - November and December (Christidis and Harrison, 1955).

2.2.3. Effect of weather parameters on growth, yield components and yield: High temperature and high relative humidity during the crop period were stated as the primary causes for low yields in cotton. Hesketh and Low (1968) observed that plants were taller, when grown under high temperature after the squaring period. Leaf area and plant weight at squaring were reduced when plants were exposed to low day/night temperatures (Moraghan *et al.*, 1968). Dry matter production at peak flowering increased with higher temperature (Thomson, 1965).

Both fruiting and boll development were found to be closely associated with night temperature. Decreased night temperature resulted in the formation of more number of flowers and increased fruit set. Temperature above 19.4 °C and below 13.3°C reduced the fruiting index (Gipson and Joham, 1968). Maximum temperature above 38°C occuring, a frotnight prior to anthesis caused anther sterility. Wind velocity, pan evaporation and total solar radiation 15 days prior to anthesis was observed to have negative association with anther sterility (Meyor, 1969, Ehlig and Lemert, 1973). Fischer, (1975) did not find any significant association between boll set and day temperature, though, he observed a highly significant negative correlation with night temperature. From their field studies Yfoulis and Fasoulas (1978) observed that under a 24 hours cycle (mean temperature 18 - 30°C), night temperature shortoned the boll period upto five times more than day temperature. A negative effect of temperature on the boll maturation period was observed by Mutasaers (1976), Nanjura and Newton (1981) and Gipson (1981). The multivariate temperature-yield analysis carried out by Lomas et al. (1976) revealed that weekly maximum temperature accounted for 28 per cent and weekly minimum temperature by 14 per cent of the variability in seed cotton yield.

Hoffman and Rawlins (1970) observed that anthers did not dehisce at low relative humidity of 25 per cent as well as at the high range of 90 per cent and the optimum was 65 per cent.

Memhan and Low (1972) observed that cotton plant required certain minimum number of heat units for each phase to occur. From flowering onwards, there appeared to be more dependence upon the heat units required. The optimum GDD (Growing degree days) was estimated to be 900 from sowing to flowering, 2100 from flowering to maturity and the total GDD was 3000 for the cropping period. It was also predicted to be possible to obtain 3000 kg of seed cotton per ha with a GDD of 2250, if the average level of solar radiation during the season was 580 cal cm^{-2} day^{-1}. Young et al. (1980) reported that the number of day degrees accumulated between sowing to boll stage and then to open boll stage was significantly less for late sown crops. The duration of boll period was shortened by diminished accumulation of day degree. The day degree units are more closely correlated from planting to maturity and from squaring to flowering, suggesting the independent response to temperature and time.

2.2.4. Solar energy conversion efficiency: The pronounced importance of light as a factor determining the dry matter production of chlorophyllous plants reveals a possibility to increase crop yield by a better use of solar energy. The efficiency of solar energy conversion of crop plants is usually calculated as a percentage of chemical energy of dry matter produced in plants in a period to the corresponding incident solar energy at the top of the plants (Hayashi, 1966).

Many of the cultural practices utilized in growing crops also have a major part of their effect through mechanism of photosynthesis. Poorly fertilized plants have low rates of photosynthesis. Optimum planting dates take advantage of light and temperature regimes of nature that best fit the photosynthetic efficiency, optimum for the species (Moss and Musgrave, 1972). In rice at booting stage, the solar energy conversion efficiency was 1.4 to 3.0 per cent (Hayashi, 1966). The photosynthetic efficiency for different cropping systems ranged from 1.583 to 2.015 per cent (Nair et al., 1973).

2.3. Effect of N on growth, yield components, yield and quality characters

2.3.1. Effect on growth characters: Linear increase in plant height in cotton with the enhancement in N levels was observed by many workers (Reddy and Rao, 1970; Gopalaswamy et al., 1974; Srnivasan et al., 1979; Aravindbabu, 1980). However, a few researchers did not observe nitrogen to have any influence on plant height (Mukerji et al., 1975; Chamy et al., 1977 and Balasubramanian, 1977).

Higher dry matter production due to N application was reported by Francies et al., (1979) and Aravindbabu, (1980). Leaf area index was found to increase upto 120 kg N/ha (Hunsigi, 1973). Growth analysis parameters like NAR, GGR and RGR were found favourably influenced by N application (Srinivasan et al., 1979 and Mayilsami, 1978). Contradictory views were put forth by Hunsigi (1973) and Bhardwaj et al.(1975), stating that these parameters were poor predictors of yield. Similarly leaf area index and NAR had no relation with yield, since, the involvement of 'sink' as the determinant of yield.

2.3.2. Effect on yield components: Increased doses of N favourably influenced the number of sympodial branches per plant (Mayilsami, 1978, and Aravindbabu, 1980). In certain instances N application did not influence the number of sympodial branches (Chamy *et al.*, 1977 and El-Debaby *et al.*, 1977). Damodaran (1975) and Jaganathan (1979) observed, N application to increase the fruiting points per plant, while, such positive effect was not observed by Kunasekaran (1978).

Nitrogen increases the yield mainly by contributing to the increase in number of bolls. Grimes *et al.* (1969) showed a close relationship between boll production and yield. The boll number contributed to about 91 per cent of the yield. However, Upadhyay and Choudhary (1971) observed, the contribution by the number of bolls to be 60 per cent of the seed cotton yield. Many research workers observed, N to have a positive influence on the boll number and boll weight (Qureshi, 1962; Balasubramanian, 1977; Jaganathan, 1979 and Aravindbabu, 1980). Bodade (1965) observed, increased boll number and weight in transplanted cotton for the application of 67.5 kg N/ha.

2.3.3. Effect on yield: The positive response of cotton to N application had been well established and about 88 per cent of variation in seed cotton yield was attributable to the effect of N(Hunsigi *et al.*, 1972). While reviewing the results of a number of trials conducted in India, Kemmler (1975) observed, an yield increase of about 5.7 kg of seed cotton per kg of N applied. The magnitude of response to applied N was found to be dependent on the initial soil fertility (Gardener and Tucker, 1967).

While reviewing the results of the manurial trials on cotton in Madras State, Mariakulandai and Morachan (1965) concluded that no uniform recommendation of fertilizers was possible. They also pointed out that separate recommendations have to be made based on the response obtained in each locality.

Chandramohan and Gopalakrishnan (1969) reported that the optimum dose of N for MCU 1 cotton was 67 kg/ha and Appadurai *et al.* (1976) observed 60 kg N/ha to be economical for the variety MCU 3, under the soil conditions of Lower Bhavani Project area of Tamil Nadu. Kamalanathan and Nagarajan (1961) and Damodaran (1975) concluded from their studies that the economic optimum dose was 40 kg/ha for irrigated cotton. Gopalaswamy and Panikar (1974) and Gopalaswamy *et al.* (1974) concluded from their manurial experiments that the optimum dose of N for the variety MCU 3 was 90 kg/ha, while, it was 103 kg/ha for MCU 5 under the soil conditions of Parambikulam

Aliyar Project area in Tamil Nadu. Mayilsami (1978) found that the optimum dose for MCU 5 under Coimbatore conditions was 60 kg/ha. Subsequently, Aravindbabu (1980) as well observed 60 kg N/ha to be optimum for MCU 9 cotton.

Balasubramanian (1977) and Chamy (1979) found that for the hybrid cotton CBS 156, the optimum dose was 120 kg N/ha. At Siruguppa in Karnataka, the hybrid variety Varalakshmi responded upto 120 kg N/ha (Koraddi et al., 1980). Bodade (1965) observed that transplanted crop responded favourably for the application of 67.5 kg N/ha as compared to significantly poor response with direct sown crop. On the contrary, non-significant response to N application was reported by Hati (1970). Instances wherein, higher levels of N to depress the yield are not uncommon. Hunsigi et al. (1972) and Rao and Weaver (1976) viewed that quadratic response for higher levels of N might be due to excessive boll drop and boll rot favoured by rank vegetative growth.

2.3.4. Effect on quality characters: Nitrogen had no favourable influence on ginning percentage (Wankhede and Sadaphal, 1977). Depressing effect of N was observed by Kanniyan et al. (1968) and Shalaby et al. (1977) due to increased seed weight without corresponding increase in lint weight.

Enhancement in applied N increased the fibre length and fibre strength of cotton (Kanniyan et al. 1968). Nitrogen did not affect the seed index (Aravindbabu, 1980). However, Shalaby et al., (1977) did not observe any depressing effect. Thus, the effect of N on quality characters was found to be inconsistent.

2.4. Effect of plant population on growth, yield components, yield and quality characters

2.4.1. Effect on growth characters: An optimum plant density is one, where, the crop should be able to make full use of the available nutrients and solar radiation to produce higher economic or biological yield. Plant height to be inversely related to the plant density was, observed by Qureshi and Khan (1974), Sinha (1974) and Fowler and Ray (1977). Lower populations reduced plant height due to more branching and supression of apical dominance (Sinha, 1974).

Under high plant density, Fowler and Ray (1977) observed, increased leaf area index owing to increased plant number through reduced land area occupied by an individual plant.

2.4.2. Effect on yield components: Fruiting efficiency decreased with the increase in plant density as a result of lower per cent of assimilates translocated in to the fruiting forms (Fowler and Ray, 1977). A decrease in boll weight and size was observed at higher plant population and reverse was the case with lower densities (Baker, 1976; Rao and Weaver, 1976). Conversely, Marani et al. (1974) reported that the population levels did not influence the boll weight and size.

2.4.3. Effect on yield: Increased yields were obtained with a population range of 70,000 to 121,000 plants/ha by Bridge *et al.* (1973) and 79,000 to 155,000 plants/ha by Fowler and Ray (1977). A population density of 44,000 plants/ha was found to be optimum for MCU 5 and MCU 9 (Venkitaswamy, 1980 and Aravindbabu, 1980). For Varalakshmi cotton, a population level of 17, 860 plants/ha with a spacing of 90 x 60 cm was found to be optimum (Koraddi *et al.*, 1980).

Absence of any influence of population density on yield was observed by many workers (Singh and Singh, 1975, Baker 1976 and Birajdar *et al.* 1977). On the other hand, increased yields were observed under higher density levels by Reddy and Rao (1970) and Upadhyay *et al.* (1977).

2.4.4. Effect on quality characters: Baker (1976) found that highest plant population produced finer fibres. Wankede and Sadapal (1977) observed that plant population had no influence on seed and lint indices. In some cases low plant density was found to increase ginning per centage (Hawkins and Peacock, 1973, Venkitaswamy, 1980).

2.5. Nutrient uptake

2.5.1. Effect of N on other nutrients: The increased uptake of P and K in plants for the application of N was observed by Francis *et al.* (1979). Plant N content was found to increase with the higher levels of N by Shanmugasundaram and Sankaran(1978).

Maximum uptake of N in plants was observed at first boll opening stage (Basinki *et al.*, 1975).

2.5.2. Effect of dates of sowing on N uptake: The uptake was higher in the early sown crops because of increase in DMP. A comparatively higher temperature regimes prevailed during the cropping period increased the mineralisation of N, resulting in more uptake (Dastur, 1959 and Burhan and Jackson, 1973).

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The scope of transplanting irrigated cotton was studied for three years from 1979-81 at the Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. The details of materials used and methods followed are presented in this Chapter.

3.1. Location

The Coimbatore Agricultural College Farm is located in the North Western Zone of Tamil Nadu at 11° north latitude and 76° 57" east longitude. The station is at an altitude of 427 metres above mean sea level.

3.2. Field and soil

The experiments were conducted in field numbers NA 1, NA 2 and 69 of the Eastern Block. The soil type of the experimental site was clay loam. The nutrient status of the soil was low in available N, medium in available P_2O_5 and high in available K_2O (Table 1). Bulk crops of fodder maize were raised in the fields without fertilization to minimise the soil heterogenity in the preceeding seasons of the experiment.

3.3. Climate and weather

The annual average rainfall of Coimbatore is 626 mm. The mean maximum and minimum temperature are 31 °C and 21.0 °C respectively. Three distinct seasons prevail in this region and they are summer, monsoon and winter with varying temperature and rainfall patterns.

Table 1. Initial soil analysis data of the experimental fields

Particulars	Experimental fields		
	Fd. No. NA 1	Fd. No. NA 2	Fd. No. 69
A. <u>Mechanical composition</u> (Percentage on oven dry basis)			
i) Clay	35.2	36.3	22.3
ii) Silt	26.5	27.1	14.5
iii) Fine sand	19.8	18.2	28.7
iv) Coarse sand	17.2	17.0	32.7
B. <u>Chemical composition</u>			
i) Available N (kg/ha)	210.3	195.2	254.4
ii) Available P_2O_5 (kg/ha)	20.5	18.2	16.9
iii) Available K_2O (kg/ha)	380.1	420.5	347.5
iv) Electrical conductivity (m.mhos/cm)	0.81	0.79	0.71
v) pH (1:2 soil : water suspension)	8.1	7.9	7.5

Experimental crops from August to April were raised in three years. The meteorological data on maximum, minimum temperatures, relative humidity, rainfall and solar radiation were recorded for the crop periods. The data are presented in Fig. 1 and Appendix 1. The data on day length at 11 °N latitude were calculated from the table published by C.F. Casella and CO, London (cited by Nadanam, 1981) and data furnished in Appendix II.

3.3.1. Day degrees and photothermal units: Growing day degree or accumulated day degrees are an arithmetic summation of daily mean temperature above a certain threshold level. These are the means for assessing plant growth, development and maturation in relation to air temperature. The degree day values were determined by subtracting a threshold constant of 12.8°C from the daily mean temperature as suggested by Wilsie (1974) and Young et al. (1980).

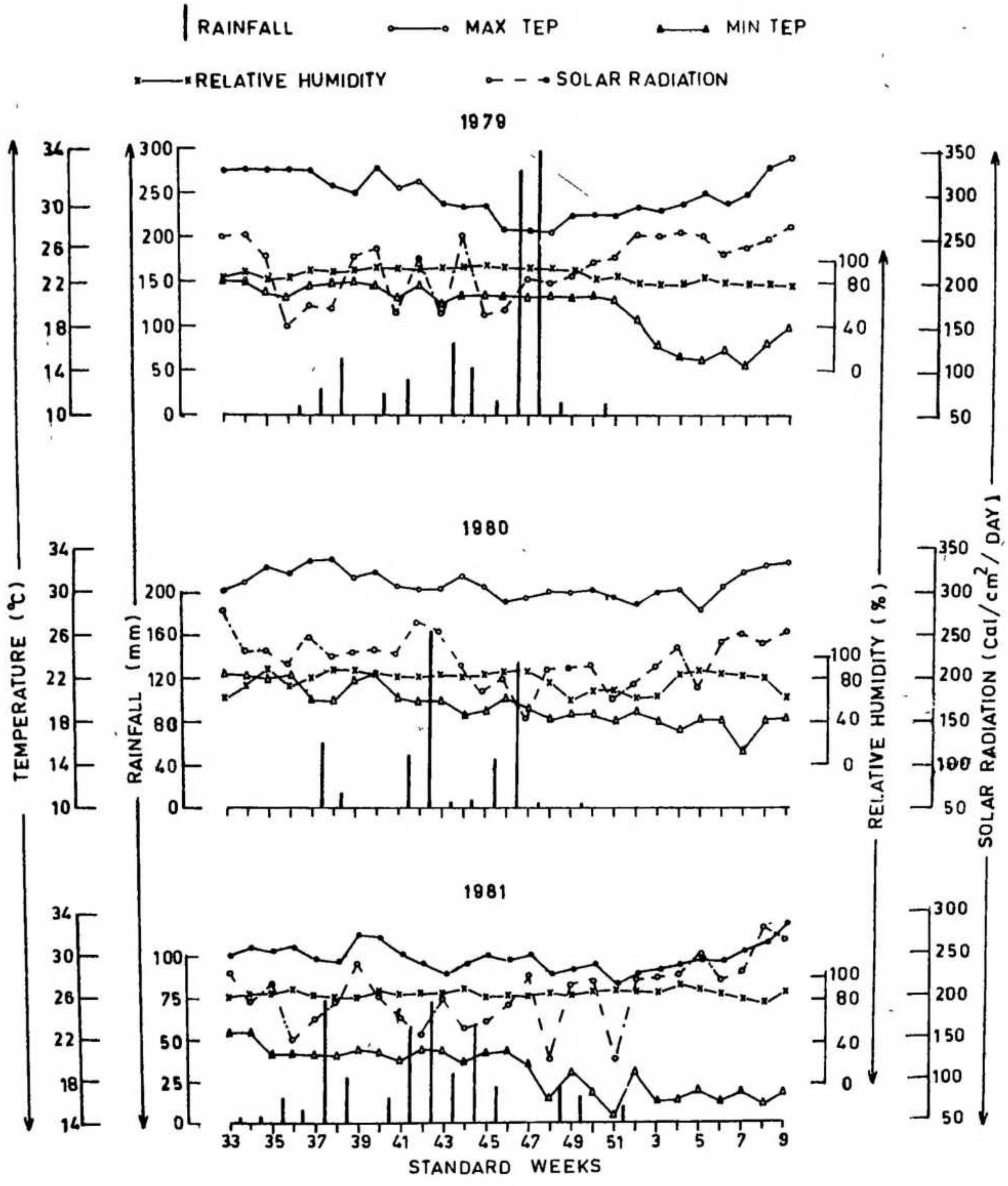
Photothermal units are obtained by multiplying day degrees with day length. Photothermal units relating to any period of growth was obtained by adding the individual units per day during that period (Appendix III).

3.3.2. Energy conversion efficiency: The solar energy conversion efficiency was worked out as suggested by Hayashi (1966).

$$\text{Solar conversion Efficiency(\%)} = \frac{\text{(Fixed energy)}}{\text{(Intercepted energy)}}$$

$$= \frac{4000 \times \text{TDM}}{\text{Total incident energy} \times 0.45} \times 100$$

FIG.1 WEATHER DATA FOR THE CROP PERIOD (1979-81)



Note: i) 1 gram dry weight was assumed equivalent to 4000 Cal.

ii) Photosynthetically effective radiation, which was assumed as 45% of the total incident radiation.

3.4. Crop and varieties

One new cotton MCU 9 (*Gossypium hirsutum*) released from TNAU during 1978 and another popular hybrid cotton Varalakshmi (*Gossypium hirsutum* x *barbadense*) released from the University of Agricultural Sciences, Dharwar were tried in the first year. Varalakshmi alone was included for the study during the second and third years.

MCU 9 is a variety derived from the Madras Cambodia Uganda varieties. It has a field duration of 160 to 165 days. Varalakshmi is the first generation (F_1) obtained from crossing Lakshmi and SB 289 E. It is highly responsive to fertilization and has field duration of 190 to 200 days.

3.5. Preparation of field

The fields were brought to fine tilth by repeated ploughing and harrowing. The plots were demarked and ridges were formed with manual labour according to the required spacings.

3.5.1. Preparation of nursery: Pai nurseries were prepared for getting the seedlings. The nursery area required was 12.5 and 25 m^2 respectively, for Varalakshmi and MCU 9 to plant one hectare of main field. Seedlings to transplant the experimental plots were raised in one square metre area in each of the varieties. Slightly raised beds were formed and levelled. Polythene sheet of 200 gauge was spread with a gunny base over the polythene sheet. Using wet mud, bunds were formed on all the four sides. About 20 kg of well decomposed farm yard manure and sand mixture (1:1) and 50 gms of di-ammonium phosphate were mixed and spread uniformly over the bed to a thickness of 5 cm. The seeds were placed on the medium, gently pressed and covered with minimum quantity of farm yard manure and sand mixture. Watering was done with rose can, twice for first three days and then once in the afternoons. One spraying of rogor (monocrotophos) at 0.03 per cent was given on 15th day.

In polythene bags of 6 cm x 10 cm size, the same medium was filled to 3/4 capacity. The seeds were placed and watered. The seedlings were maintained as in the case of pai nursery.

3.6. Experimental details

Experiments were conducted during the winder seasons of the years 1979, 1980 and 1981 with different treatments. In the first year, two methods of nursery with different ages of seedlings were compared under the normal date of sowing. The results indicated that the variety Varalakshmi was superior to MCU 9 in seed cotton yield. Pai nursery was better than polythene bags in respect of cheapness, ease of raising and handling. Twenty day old seedling recorded almost equal yield to that of direct sowing, while 60 day old seedling produced significantly lower yield. Based on the results, the treatments were modified in the second year. Thirty and 45 day old seedlings were compared with direct sowings under three dates and three nitrogen levels with Varalakshmi alone. In the third year the nitrogen levels were eliminated as the results confirmed the recommended levels and also the transplanted crops did not differ in their response. Two population levels were included to find out whether the yield loss under late sown conditions could be made good by increased population. In addition to 30 and 45, 20 day old seedling were included to assess the possibility of getting increased yield.

3.6.1. Design and layout: Randomised blocks design in the first year and split plot design in the second and third years with three replications were followed. The details are as follows:

Winter, 1979

Treatment	Cultivar	Age of seedling	Method of nursery
1	MCU 9	20 day	Pai nursery (PN)
2	MCU 9	40 day	Pai nursery (PN)
3	MCU 9	60 day	Pai nursery (PN)
4	MCU 9	20 day	Polythene bag (PB)
5	MCU 9	40 day	Polythene bag (PB)
6	MCU 9	60 day	Polythene bag (PB)
7	MCU 9	Direct sowing	

Treatment	Cultivar	Age of seedling	Method of nursery
8	Varalakshmi	20 day	Pai nursery (PN)
9	Varalakshmi	40 day	Pai nursery (PN)
10	Varalakshmi	60 day	Pai nursery (PN)
11	Varalakshmi	20 day	Polythene bag (PB)
12	Varalakshmi	40 day	Polythene bag (PB)
13	Varalakshmi	60 day	Polythene bag (PB)
14	Varalakshmi	Direct sowing	

Design - Randomised blocks design

Replication - Three

Plot size - Gross - 4.5 m x 7.2 m

Net - 3.0 m x 6.6 m (MCU 9)

2.7 m x 6.0 m (Varalakshmi)

Spacings : 90 cm x 60 cm (Varalakshmi)

75 cm x 30 cm (MCU 9)

Seedlings of different ages were obtained from the same nursery raised on the date of direct sowing in the main field (14.8.79).

Winter 1980	Winter 1981
Treatments	
a. Main plot: (Date of sowing x Nitrogen level)	(Date of sowing x Population level)
Date of sowing	Date of sowing
i) 14th August	i) 14th August
ii) 29th August	ii) 29th August
iii) 13th September	iii) 13th September

Nitrogen level	Population level
i) Recommended level 120 kg/ha (N_{120})	Normal, 17,860 pl/ha (P_{18})
ii) 25% less of recommended level 90 kg/ha(N_{90})	25% more : 22,222 pl/ha (P_{22})
iii) 25% more of recommended level 150 kg/ha (N_{150})	

b. Sub-plot

Age of seedling

i) Direct sowing	i) Direct sowing
ii) 30 day old seedling (30 day)	ii) 20 day old seedling (20 day)
iii) 45 day old seedling (45 day)	iii) 30 day old seedling (30 day)
	iv) 45 day old seedling (45 day)

Design - Split plot

Replication - Three

Plot size -	Gross - 7.2 m x 5.4 m	Gross: 7.2 m x 5.4 m
	Net - 3.6 m x 4.2 m	Net : (P_{18}) -3.6 m x 4.2 m
		(P_{22}) -3.6 m x 4.5 m
Spacing:	90 cm x 60 cm	P_{18} - 90 cm x 60 cm
		P_{22} - 90 cm x 45 cm

Different ages of seedling for different dates of transplantings were obtained from the nurseries raised in advance.

3.6.2. Sowing and transplanting: Acid delinted cotton seeds were dibbled at 2 seeds in MCU 9, and one seed in Varalakshmi. Only one seedling per hill was transplanted after irrigating the field as practised in the case of millets. After recording the establishment/germination counts, gap filling with seeds and seedlings was done on 9th and 4th day, respectively. Thinning in the case of direct sown crops was done on 15th day, leaving one plant per hill.

3.7. Manures and fertilizers

3.7.1. Nitrogen: In the first year N was applied at 60 and 120 kg/ha, respectively, for MCU 9 and Varalakshmi in three splits. In the second year it was applied as per treatments, while, in the third year it was applied at 120 kg/ha, since Varalakshmi alone was used.

3.7.2. Phosphorus: In the first year P was applied at 30 and 60 kg P_2O_5/ha respectively, for MCU 9 and Varalakshmi. In the second and third years 60 kg P_2O_5/ha was applied.

3.7.3. Potassium: During the first year potassium was applied at 30 and 60 kg K_2O/ha, respectively, for MCU 9 and Varalakshmi. It was applied at 60 kg/ha during the second and third years.

3.8. After cultivation

Two hoeings and weeding, one hand weeding on 20th and 40th day and earthing up on 60th day were given . Irrigations were given at 25 per cent available moisture in the soil. Need based plant protection measures were adopted as per the recommendation of the Tamil Nadu Agricultural University.

3.9. Harvest

Opened bolls were harvested at weekly intervals.

3.10. Biometric observations

3.10.1. Growth characters: The following observations were recorded from five plants selected at random in each plot and mean values were worked out.

3.10.1.1. Plant height: Plant height was measured at squaring, flowering and maturity periods and expressed in cm.

3.10.1.2. Leaf area index (LAI): Leaf area was measured as suggested by Irudayaraj and Sivaraj (1979). The LAI was computed by dividing the leaf area of a plant by the land area occupied by it.

3.10.1.3. Dry matter production (DMP): Samples were collected at squaring, flowering and at maturity from the sampling rows. The plants were separated in to different parts, the weights were recorded on moisture free basis and computed to kg/ha.

3.10.2. Yield components

3.10.2.1. Number of monopidia: The number of monopodial branches arising from axillary buds were counted at maturity of the crop.

3.10.2.2. Number of sympodia: The sympodial branches arising from extra-axillary buds were counted at maturity.

3.10.2.3. Number of fruiting points: Total number of fruiting points per plant was recorded at final harvest.

3.10.2.4. Number of bolls per plant: The total number of bolls picked at each picking till the completion of harvest were summed up.

3.10.2.5. Setting per cent: The setting per cent was worked out from the number of fruiting points and total number of bolls harvested.

3.10.2.6. Boll weight: The weight of matured bolls picked from the tagged plants were recorded and expressed in g/boll.

3.10.3. Quality characters

3.10.3.1. Earliness: The number of days taken to attain 50 per cent flowering, number of days to first boll opening and per cent of seed cotton harvested to the total on 150th day were taken to determine the earliness as suggested by Sivasubramanian (1962).

3.10.3.2. Ginning per cent: It denotes the ratio of the weight of the lint to the weight of the seed cotton expressed in per cent. Duplicate samples, each having 100 seed cotton from each plot were weighed and after ginning, seeds were weighed separately.

3.10.3.3. Lint index: The weight of lint obtained from 100 seeds was expressed in grams.

3.10.3.4. Seed index: The weight of seeds obtained from 100 seed cotton was expressed in grams.

3.10.3.5. Mean fibre length: The mean fibre length was determined by 'Ball's sorter' and expressed in mm (Sundaram and Iyengar, 1968).

3.10.3.6. Mean fibre fineness: It is the measure of fibre weight in µg/g unit length of fibre. It was determined with the help of a micronaire.

3.10.3.7. Bundle strength: It is the ratio of the breaking strength of a bundle of fibres to its weight. Duplicate tufts of fibres, weighing one mg were fed in to the 'Pressely strength Tester' which gave reading in lb/mg. The value was expressed in g/tex by multiplying the pressley strength index with factor 5.36.

3.10.3.8. Maturity coefficient: It is the ratio of the mature, half mature and immature fibres in a sample of lint. It was determined by using micronaire instrument by air flow method as suggested by Sundaram and Iyangar (1968). A sample of 3.24 g of lint was fed into the instrument and compressed air was allowed to pass through the sample with and without spacer and the difference between the two readings were noted and referred to a standard table which indicated the maturity coefficient directly.

3.11. Chemical analysis

3.11.1. Plant analysis: The plants collected for dry matter estimation were used and the dried samples were ground and analysed for N, P and K.

3.11.1.1. Nitrogen: Nitrogen was estimated using micro-kjeldahl method suggested by Yoshida et al. (1972) and expressed as per cent on oven dry basis. The uptake was computed to kg/ha.

3.11.1.2. Phosphorus: Total P was estimated by triple acid digestion method described by Jackson (1973) and estimation was done colorimetrically using photo-electric colorimeter and expressed as per cent on oven dry basis. The uptake was computed to kg/ha.

3.11.1.3. Potassium: K content was estimated using triple acid method (Jackson, 1973) with flame photometer and expressed as per cent on oven dry basis. The uptake was calculated to kg/ha.

3.12. Statistical analysis

The data were analysed as per methods applicable for the randomised blocks and split plot designs. Correlation and regression analysis were also done with meteorological data collected (Snedecor and Cochran, 1967).

Results and Discussion

CHAPTER IV
RESULTS AND DISCUSSION

The results of the field experiments conducted at Tamil Nadu Agricultural University, Coimbatore during the winter seasons of 1979 through 81, relating to the studies on transplanting of irrigated cotton are presented and discussed in this chapter under Part A and Part B.

PART A

Studies on the nursery methods and age of seedlings (Winter 1979)

PART B

Studies on the age of seedlings under different dates of sowing and transplanting, nitrogen and population levels (Winter 1980 and '81).

4.1. Season

The thirty years mean data on weather parameters (1951-'80) indicate that the Coimbatore tract enjoys a mild warm climate. The warmest month is April (35 °C and 23 °C maximum and minimum, respectively) and the cooler month is January (maximum temperature 29 °C and minimum temperature 17.8°C). The vapour pressure deficit shows that the atmosphere is saturated during October (75.5% Rh) and drier during

March (58% Rh). Coimbatore receives just 650 mm of rainfall in 42 rainy days, nearly 50 per cent of which is accounted for during the North-east monsoon. Coimbatore has clear sunshine for 10 hr/day during March and a minimum of 4.3 hr/day during July.

In general, the weather factors during 1979 were normal, except rainfall. A total of 1300 mm of rainfall was received during the year in 59 rainy days, which was a record high for 80 years. In November alone 664 mm of rainfall was recorded, which was equivalent to an year's normal rainfall.

During the cropping period of 1980, the mean maximum and minimum temperature were 30.9 and 19.8 °C as against the 30 years average of 30.0 and 21.1 °C respectively. The solar radiation received ranged from 180 to 280 Cal cm^{-2} day^{-1}. The total rainfall recorded was 484 mm during the crop period in 19 rainy days as against 443 mm in 30 rainy days of 30 years average.

During the cropping period of 1981, the mean maximum and minimum temperature were 29.9 and 19.2 °C. The solar radiation received was from 138 to 281 Cal cm^{-2} day^{-1}. The total rainfall received during the cropping period was 243 mm.

In general there were not much variations in respect of temperature, relative humidity and solar radiation levels among the cropping seasons, except the abnormal rainfall during the cropping season of 1979 and below normal in the cropping season of 1981.

PART A

Studies on the nursery methods and age of seedling.

4.2. Seedling height (Table 2)

Varalakshmi was taller than MCU 9 true to the genetic make up. The seedlings raised in polythene bags were taller than those from pai nursery. The availability of more foraging medium for each of the seedling can be attributed to the tallness.

In the pai nursery, the height of seedlings (both Varalakshmi and MCU 9) increased with the age, eventhough, the rate of increase was smaller with the ageing. Beyond 40 days, the availability of nutrients in the medium would have been a limiting factor for the smaller increase in growth observed. However, the progressive increase in height of the seedling from the polythene bags was directly proportional to the age. The greater availability of nutrients from polythene bag could be the reason for the differences in growth rate. Similar pattern of growth of the seedlings in pai nursery was observed by Arunachalam and Ramanujam (1981).

Table 2. Seedling height of cotton and establishment in the main field

Characters	Seedling height (cm)			Establishment(%)		
Treatment	R.N.	P.B.	Mean	P.N.	P.B.	Mean
20 day	7.6	10.6	9.1	98.1	98.7	98.4
40 day	14.5	17.4	16.0	96.5	97.5	97.0
60 day	18.4	25.6	22.0	85.6	97.6	91.6
Direct sowing	-	-	-	-	-	86.5
Mean	13.5	17.8		93.4	97.9	
MCU 9			13.2			92.1
Varalakshmi			18.1			94.5

	$S.E_{D.}$	C.D.(P=0.05)
Variety	1.22	N.S.
Methods of nursery	1.82	N.S.
Ages	1.82	3.73
Methods x Ages	3.82	7.88

N.S. = Not significant

4.3. Establishment of seedlings in the main field (Table 2)

The optimum plant stand in the main field is largely determined by the germination capacity of the seeds in the case of direct sown crop, while, in the transplanted crop, it depends on the establishment of seedlings after transplanting. The extent of establishment of seedlings in the main field was as high as 92 to 98 per cent, while, the germination was only 86 per cent with the direct sown crop. The extent of establishment with MCU 9 and Varalakshmi, respectively, was 92 and 94 per cent.

The success of establishment of the 60 day old seedlings from pai nursery was, however, lower as compared to the 20 or the 40 day old seedling. This could be attributed to the loss of tender fibrous roots when, the seedlings were removed from the nursery on account of ramification of the roots. Such differences were not recorded with the seedlings from polythene bags as they were transplanted intact, without disturbing the root system.

4.4. Growth components

4.4.1. Plant height (Table 3): Plant height is an indicator of growth performance of the crop as influenced by the environmental and management factors. Varalakshmi was taller than MCU 9 at maturity. Varalakshmi being a hybrid, put forth greater growth than MCU 9. The direct seeded plants were taller than the transplanted ones. As the age of the seedlings increased, a progressive decrease in plant height was observed. The plant height from the polythene bag nurseries were comparable with that from the pai nursery. With the increase in the age of seedling at transplanting, the plant height at harvest decreased progressively.

Vegetative phase decreased progressively, when seedlings of higher age were transplanted. The early change in the physiological phases, might have resulted in the diversion of available photosynthates to the developing reproductive organs to a greater proportion than to the meristomatic 'sinks'.

4.4.2. Leaf area index (LAI) (Table 3): LAI determines the total photosynthesizing area available to the plant and the quantum of source that would be ultimately available for translocation to the sink. Varalakshmi produced greater LAI. In general LAI of both the varieties was lower. This might be due to continuous rainfall coupled with reduced levels of solar radiation, leading to reduced growth and development of leaves.

The LAI values did not differ among the methods of nursery. LAI was larger with the direct seeded crop than in the transplanted ones. However, the LAI with the 20 day old seedling was comparable with that of the direct seeded crop. The LAI from the 60 day old seedling was smaller than that from the 40 day old seedling. The decline in the LAI values in aged seedlings might be due to their physiological ageing which reduced the grand growth phase of the crops in the main field.

Table 3. Plant height, leaf area index and dry matter production in cotton

Characters	Plant height (cm)			Leaf area index			Dry matter production (kg/ha)		
Treatment	P.N.	P.B.	Mean	P.N.	P.B.	Mean	P.N.	P.B.	Mean
20 day	117.6	113.5	115.5	4.6	4.8	4.7	7318	6116	6717
40 day	92.6	99.8	96.2	4.1	4.3	4.2	6816	6248	6532
60 day	78.6	84.0	81.3	3.2	3.4	3.3	4140	4219	4180
Direct sowing	-	-	128.0	-	-	5.1	-	-	6842
Mean	96.2	99.1		4.0	4.2		6091	5527	
MCU 9			91.3			4.0			5465
Varalakshmi			118.9			4.6			6449

	S.E$_D$.	C.D.(P=0.05)	S.E$_D$.	C.D.(P=0.05)	S.E$_D$.	C.D.(P=0.05)
Variety	4.0	8.1	0.16	0.32	160	328
Methods of nursery	4.2	N.S.	0.18	N.S.	280	N.S.
Ages	4.2	8.6	0.18	0.36	280	575

Note : Interactions are not significant
N.S. : Not significant

4.4.3. Dry matter production (DMP) (Table 3): Dry matter production of a crop reflects its efficiency of utilisation of available resources such as solar energy, moisture and nutrients, under a given environmental condition.

The DMP at harvest was greater in Varalakshmi than in MCU 9. This is a reflection of the increased LAI and higher plant height observed with Varalakshmi. The DMP with the 20 day old seedling was higher than that from the 60 day old seedling and was comparable with that of the direct seeded crop and the 40 day old seedling. Sixty day old seedling produced the lowest weight of dry matter due to its poor growth as reflected in plant height and LAI.

4.5. Yield components and yield

4.5.1. Monopodial branching (Table 4): Generally more number of monopodial branches results in greater vegetative growth. Monopodial branches were more in Varalakshmi than in MCU 9.

Seedlings transplanted from pai nursery and polythene bags did not differ among themselves in this character.

The 20 and the 40 day old seedlings produced comparable number of branches with that of the direct seeded crop, while, the 60 day old seedling produced less number of branches due to shorter vegetative period in the field.

Table 4. Number of monopodia, sympodia and fruiting points in cotton

Character	Monopodia per plant			Sympodia per plant			Number of fruiting points per plant		
Treatment	P.N.	P.B.	Mean	P.N.	P.B.	Mean	P.N.	P.B.	Mean
20 day	2.75	2.36	2.55	29.06	28.10	28.58	73.4	77.8	75.6
40 day	2.25	2.93	2.59	28.40	28.86	28.63	68.1	73.4	70.9
60 day	1.10	1.46	1.28	21.90	20.01	20.95	40.5	45.0	42.5
Direct sowing	-	-	2.35	-	-	28.81	-	-	80.0
Mean	2.03	2.25		26.45	25.65		60.7	65.5	
MCU 9			1.87			25.6			60.0
Varalakshmi			2.47			27.3			74.5

	$S.E_{D.}$	C.D.(P=0.05)	$S.E_{D.}$	C.D.(P=0.05)	$S.E_{D.}$	C.D.(P=0.05)
Variety	0.26	0.55	0.26	0.53	3.2	6.6
Method of nursery	0.45	N.S.	0.29	N.S.	3.8	N.S.
Ages	0.45	0.92	0.29	0.60	3.8	7.8

Note : Interactions are not significant
N.S. : Not significant

4.5.2. Sympodial branching (Table 4): Sympodial branches that arise from extra axillary buds are more important as they bear the most of the flower buds. More number of sympodial branches was observed in Varalakshmi.

The number of sympodial branches from pai as well as polythene bags was comparable. The transplanted crops with the 20 and the 40 day old seedlings produced as many sympodia as in direct seeded crop. Sympodia from the 60 day old seedling were fewer.

4.5.3. Number of fruiting points per plant (Table 4): Fruiting points in Varalakshmi were more than in MCU 9. The number of fruiting points were not influenced by different nursery methods.

Greater number of fruiting points was observed in the direct seeded crop which was on par with that from the 20 day old seedling. The number of fruiting points was the least with the 60 day old seedling, as a result of less number of sympodial and monopodial branches.

4.5.4. Number of bolls per plant (Table 5): Among the yield components, boll number per plant exerted greater influence on the seed cotton yield. Higher number of bolls per plant was observed in Varalakshmi as compared to that in MCU 9, as a consequence of increased number of fruiting points.

Seedlings from the pai nursery or the polythene bag were of no consequence in the production of bolls. The number of bolls produced per plant by the 20 day seedling was on par with the direct seeded crop. The 60 day old seedling recorded less number of bolls per plant owing to lesser number of fruiting points, monopodial and sympodial branches.

4.5.5. Boll weight (Table 5): Boll weight of MCU 9 was significantly higher than that of Varalakshmi. The reason for this variation might be that Varalakshmi produced almost double the number of bolls per plant. The nursery methods had no effect on the boll weight.

The 20 day old seedling produced heavier bolls than the 40 and the 60 day old seedlings and was on par with the direct seeded crop. The boll weight was the least with the 60 day old seedling. The reason for this may be due to insufficient leaf area developed to make effective use of the available solar energy.

4.5.6. Setting per cent (Table 5): Varalakshmi recorded higher boll setting per cent than MCU 9. Boll setting per cent did not differ with the method of nursery. The setting per cent was not influenced by ages at transplanting, eventhough, there were significant variations in the number of fruiting points and the number of bolls produced.

Table 5. Number of bolls, boll weight and setting per cent in cotton

Characters	Number of bolls/plant			Boll weight (g/boll)			Setting per cent		
Treatment	P.N.	P.B.	Mean	P.N.	P.B.	Mean	P.N.	P.B.	Mean
20 day	26.1	24.5	25.3	3.90	3.83	3.86	33.8	31.6	32.8
40 day	21.0	22.5	21.8	3.64	3.54	3.59	30.1	31.9	31.0
60 day	15.2	12.6	13.9	2.86	2.97	2.92	32.5	32.9	31.5
Direct sowing	-	-	25.2	-	-	3.74	-	-	31.5
Mean	20.7	19.9					32.1	32.0	
MCU 9			15.8			3.71			29.1
Varalakshmi			27.3			3.26			34.9

	$S.E_D.$	C.D.(P=0.05)	$S.E_D.$	C.D.(P=0.05)	$S.E_D.$	C.D.(P=0.05)
Variety	1.54	3.16	0.10	0.21	0.60	1.21
Methods of nursery	1.67	N.S.	0.11	N.S.	0.64	N.S.
Ages	1.67	3.42	0.11	0.22	0.64	N.S.

Note : Interactions are not significant
N.S. : Not significant

4.6. Yield of seed cotton (Table 6)

Seed cotton yield from Varalakshmi was higher than from MCU 9. Phenomonoly higher boll number and greater setting per cent observed with Varalakshmi contributed to this higher yield, eventhough, the bolls were lighter. Seed cotton yield from the seedlings of pai was comparable with that from polythene bag. The seed cotton yield from the 20 day old seedling was greater than that from the older seedlings and was comparable with that from the direct seeded crop. The seed cotton yield from the 40 day old seedling was higher than that from the 60 day old seedling. The quantum of the seed cotton produced by the 20 day old seedling was 97.3 per cent, the 40 day old seedling 79.6 per cent and the 60 day old seedling 43.7 per cent of the yield obtained from the direct seeded crop. Thus, the use of young seedling is as good as direct seeding. The yield tended to decrease with delay in transplanting.

The method of nursery was of no consequence in yielding ability .

The considerable yield reduction with the 60 day old seedling was because of less number of bolls with reduced weight. A progressive decline in yield with the increase in age of the seedling was reported by Arunachalam and Ramanujam (1981).

Table 6. Seed cotton yield and nitrogen uptake in cotton

Characters	Seed cotton (q/ha)			Nitrogen uptake (kg/ha)		
Treatment	P.N.	P.B.	Mean	P.N.	P.B.	Mean
20 day	17.10	18.32	17.71	115.2	107.4	111.3
40 day	14.90	15.22	15.06	97.8	90.8	94.3
60 day	7.81	8.71	8.26	69.1	72.6	70.8
Direct sowing	-	-	18.19	-	-	105.5
Mean	13.27	14.08		94.0	90.2	
MCU 9			12.9			89.6
Varalakshmi			16.7			101.2

	$S.E_{D.}$	C.D.(P=0.05)	$S.E_{D.}$	C.D.(P=0.05)
Variety	0.44	0.89	4.21	8.45
Methods of nursery	0.61	N.S.	7.42	N.S.
Ages	0.61	1.27	7.42	15.22

Note : Interactions are not significant

N.S. = Not significant

4.7. Nitrogen uptake (Table 6)

The uptake of N was greater in Varalakshmi than in MCU 9, as a result of increased dry matter production.

The transplanted crop with the seedlings from different nurseries did not differ in the uptake of N.

The uptake was more with the 20 day old seedling as compared to the 40 and the 60 day seedlings and was on par with the direct sown crop. The uptake was the lowest with the 60 day old seedling, closely following the trend of dry matter production.

4.8. Crop duration (Table 7)

Field duration of the crop is important in the adoption of multiple cropping systems. The total field duration of the direct sown crop was 172 and 195 days for MCU 9 and Varalakshmi, respectively. A gradual reduction in the number of days taken to flower, to boll open stage and in total field duration was observed with the increase in age of seedlings. The reduction in field duration was by 7 to 10 days in the case of the 20 day old seedling, 24 to 28 days with the 40 day old seedling and it was 36 days under the 60 day old seedling. Similar reductions in field duration were observed by Arunachalam and Ramanujam (1981).

Table 7. Field duration of cotton (days)

Variety	Age of the seedlings	First flowering	First Boll opening	Total duration
MCU 9	Direct sowing	60	120	172
	20 day	58	115	165
	40 day	51	101	148
	60 day	46	96	136
Varalakshmi	Direct sowing	63	125	190
	20 day	60	120	180
	40 day	53	109	162
	60 day	48	101	156

4.9. Economics (Table 8)

The economics of raising seedlings through polythene bags and *pai* nursery was worked out and compared with the direct sowing. The cost of production of seedlings raised through polythene bags to plant one hectare of the main field worked out to Rs 853 and Rs 421 respectively for MCU 9 and Varalakshmi. The comparatively high cost incurred was due to the increased labour charges for filling up and sowing the seeds in the polythene bags, besides, the cost of the bags. The cost of production of seedlings in MCU 9 was twice as that of Varalakshmi because of higher population.

In the case of *pai* nursery, the cost incurred was Rs 240 and Rs 202, respectively, for MCU 9 and Varalakshmi as against Rs 348 and Rs 315 for the direct seeding. Thus, the saving was Rs 108 for MCU 9 and Rs 117 for Varalakshmi as compared to their respective direct sown crops.

On comparing the cost factor and ease of raising, *pai* nursery was found more viable for large scale adoption. In view of the lesser nursery area required, high cost of seeds and longer duration of the crop, adoption of *pai* nursery for raising seedlings was more advantageous with Varalakshmi than MCU 9.

4.10. Summary of results

As a first phase in the three year research programme, a field experiment was conducted during the winter season, 1979.

Table 8. Economics on nursery in cotton

S.No.	Particulars	Amount Rs. nP
a.	Raising seedlings through polythene bag	
	i) MCU 9	
	1. Cost of polythene bag at Rs.12/1000 for 44,000 bags	552.00
	2. Cost of 10 kg of seeds	75.00
	3. Filling with medium, sowing seeds, watering and plant protection measures	98.50
	4. Transplanting	102.50
	Total	828.00
	ii) Varalakshmi	
	1. Cost of polythene bags at Rs.12/1000 for 18,000 bags	216.00
	2. Cost of 2 kg of seeds	120.00
	3. Cost of filling, sowing seeds, watering and plant protection	40.00
	4. Transplanting charges	45.00
	Total	421.00
b.	Raising seedlings through 'Pai' nursery	
	i) MCU 9	
	1. Cost of 3 kg of polythene sheet at Rs.18/kg and old gunny bags	60.00
	2. Cost of 10 kg of seeds	75.00
	3. Labour charges for making beds, sowing, watering and plant protection	25.00
	4. Pulling out and transplanting	80.00
	Total	240.00

(Continued)

Table 8 (Continued)

S.No.	Particulars	Amount Rs. np.
	ii) Varalakshmi	
	1. Cost of 1.5 kg of polythene sheet and old gunny bags	27.00
	2. Cost of 2 kg of seeds	120.00
	3. Labour charges for forming beds, filling, sowing, watering and plant protection	15.00
	4. Transplanting	40.00
	Total	202.00
c.	Direct sowing	
	i) MCU 9	
	1. Cost of 15 kg of seeds	112.00
	2. Dibbling charges	140.00
	3. Plant protection	75.00
	4. Thinning and gap filling	21.00
	Total	348.00
	ii) Varalakshmi	
	1. Cost of 2.5 kg of seeds	150.00
	2. Dibbling charges	78.00
	3. Plant protection	80.00
	4. Gap filling	8.00
	Total	319.00

The objectives were to evaluate the performance of two cotton cultivars, two methods of raising seedlings and three ages of seedlings along with a direct sown crop.

The results indicated that, Varalakshmi was superior to MCU 9 in respect of seed cotton yield. Raising seedlings in _pai_ nursery was found to be economical, easier and offered scope for large scale adoption as compared to raising seedlings in polythene bags. Establishment of seedlings in the main field was as high as 98 per cent in transplanted crops as against 86 per cent under direct sowing. The yield of seed cotton with the 20 day old seedling was comparable with that of direct sown crop. An yield reduction by 56 per cent with the 60 day old seedling as compared to the direct sown crop was observed.

In the light of the above results, the variety MCU 9, raising seedlings in polythene bags and the 60 day old seedling were deleted from the treatments tried in the subsequent years.

PART B

The results of the experiments on the studies with age of seedlings under different date of sowings, nitrogen and population levels are presented and discussed.

4.11. Establishment of the seedlings in the main field (Table 9)

For harvesting the solar energy in the production of the end product, optimum population is essential. The per cent of establishment of seedlings in the main field was 95 to 98 in both the cropping seasons under all date of sowings and transplantings. However, the germination of seeds with the direct sown crop was only 92 per cent.

The results of the present study indicate that higher plant stand could be achieved through transplanting than with the conventional sowing of seeds. The other advantages observed with the transplanted crop were (i) the gap filling could be done on the 4th day itself as against 10 th day in the direct sown crops. (ii) the cost of thinning could be eliminated as only one seedling was transplanted.

4.12. Growth components (Table 9)

4.12.1. Plant height: The plant height at maturity was influenced by the date of sowings and transplantings. There was a progressive reduction in the height under the delayed sowings and transplanting from 14th August to September 13th in both the years. The reduction might have been brought out by the differential effect of weather parameters prevailed during the crop period. Chamy and Balasubramanian (1976) observed a similar reduction in plant height with late sown direct seeded crops.

Application of 150 kg N/ha increased the plant height over that from 120 or 90 kg N/ha in the transplanted and the direct sown crops. The results are in confirmity with the known influence of N on the growth as observed by Aravindbabu (1980).

Both the direct sown and the transplanted crops were taller under high population level. This might be due to the well pronounced apical dominance. Similar observations were made by Venkitaswamy (1980) and Galonopoulou <u>et al</u>. (1980).

The direct sown crops were taller than transplanted crops. In the year 1980, the plant height did not differ with the age of seedling, while, during 1981, the plant from the 20 day old seedling was taller than 45 day old seedling. The overall reductions in plant height with transplanted crop might be due to a lag growth period that occured during the establishment stage as is observed in other crops. Besides, there was an early shift from vegetative to reproductive phase. A part of photosynthates might have been diverted to reproductive sinks which would have otherwise been available for the vegetative growth.

4.12.2. <u>Leaf area index (LAI)</u> (Table 9) : The LAI values recorded at maturity showed a progressive reduction as the sowings and transplantings were delayed from 14th August to 13th September. The cause for this might be, the prevalence of varied weather conditions during the growth period.

Table 9. Establishment of seedling, plant height at maturity and leaf area index (LAI) of cotton

Treatment	Establishment(%)		Plant height (cm)		LAI	
	1980	1981	1980	1981	1980	1981
14th August	94.6	96.5	134.3	130.8	5.7	5.8
29th August	94.9	95.2	123.9	115.6	5.2	5.2
13th September	96.1	96.1	113.8	106.7	4.4	4.7
$S.E_{D.}$	1.92	1.61	4.3	3.0	0.19	0.12
C.D.(P=0.05)	N.S.	N.S.	9.1	6.6	0.42	0.27
N_{90}	96.9	-	119.2	-	4.8	-
N_{120}	94.5	-	125.3	-	5.0	-
N_{150}	94.2	-	133.2	-	5.4	-
$S.E_{D.}$	1.92	-	4.3	-	0.19	-
C.D.(P=0.05)	N.S.	-	9.1	-	0.42	-
P_{18}	-	94.9	-	123.1	-	5.1
P_{22}	-	96.8	-	136.4	-	5.4
$S.E_{D.}$	-	1.61	-	3.0	-	0.12
C.D.(P=0.05)	-	N.S.	-	6.6	-	0.27
Direct sowing	91.8	92.9	136.7	141.2	5.5	5.7
20 day	-	96.5	-	128.2	-	5.5
30 day	96.2	97.6	123.4	126.6	5.0	4.9
45 day	97.6	96.6	124.3	123.1	4.6	4.8
$S.E_{T.}$	1.31	1.26	3.7	2.1	0.16	0.19
C.D.(P=0.05)	2.65	2.55	7.4	4.5	0.32	0.38

Note : Interactions are not significant
N.S. : Not significant

The LAI at 150 kg N/ha was comparable with that at 120 kg and larger than at 90 kg N/ha. The higher values were the consequence of the increased plant height. Similar findings on the effect of N on LAI were reported by Basinski et al., (1975).

Greater LAI values were recorded under the high population level (P_{22}). The higher values were due to the increased number of plants per unit area with reduced land area occupied by an individual plant. Fowler and Ray (1977) observed similar effects of population on LAI.

The direct seeded crops had more leaf area than the transplanted one. In 1980, the 30 day old seedling had higher LAI than the 45 day old seedling and was, however, lower to that in the direct seeding. In 1981, the LAI in the 20 day old seedling was on par with the direct seeded crop and was higher than from the 30 and the 45 day old seedlings. The optimum LAI computed through a quadratic equation was found to be 5.1.

4.12.3. Dry matter production (DMP)

The data on the total dry matter produced and accumulated in the reproductive parts at squaring, flowering and maturity stages are discussed under respective stages.

Table 10. Dry matter production in cotton at squaring (kg/ha)

Treatment	Total		Reproductive parts	
	1980	1981	1980	1981
14th August	610	516	23	23
29th August	485	426	23	20
13th September	403	384	24	19
S.E$_D$.	38	32	1.5	1.7
C.D.(P=0.05)	80	71	N.S.	N.S.
N_{90}	445	-	23	-
N_{120}	514	-	24	-
N_{150}	540	-	23	-
S.E$_D$.	38	-	1.5	-
C.D.(P=0.05)	80	-	N.S.	-
P_{18}	-	582	-	27
P_{22}	-	590	-	28
S.E$_D$.	-	32	-	1.7
C.D.(P=0.05)	-	N.S.	-	N.S.
Direct sowing	525	454	23	20
20 day	-	453	-	21
30 day	515	446	25	22
45 day	460	387	23	22
S.E$_D$.	21	19	1.2	1.3
C.D.(P=0.05)	44	42	N.S.	N.S.

Note : Interactions are not significant
N.S. : Not significant

i) Squaring stage (Table 10) : The crops sown and transplanted on 14th August produced higher dry matter than at the other dates which did not differ between themselves. The increase in DMP in the early sowing might have been due to comparatively higher solar radiation levels and temperature.

The levels of N did not influence the DMP as the period might have been too short to exert any perceptible effect. Halevy (1976) observed that the rate of demand for nutrients in the early stages was slow.

Population levels as well, did not influence the DMP as there would not have been much competition for growth factors during the early stages of growth.

The DMP was considerably lower in the crops raised from the 45 day old seedling than from the direct seeded, the 20 and the 30 day old seedlings. This might be due to the availability of shorter period for growth after the establishment.

Accumulation of DM in reproductive parts did not differ with different treatments.

ii) Flowering stage (Table 11): Progressive reductions in DMP were recorded as the sowing and transplanting were delayed during 1980. In 1981, the DMP from the crops sown and transplanted on 14th August was on par with that from 29th August and was greater than from 13th September sown crops.

Table 11. Dry matter production in cotton at flowering (kg/ha)

Treatment	Total		Reproductive parts	
	1980	1981	1980	1981
14th August	1458	1385	343	336
29th August	1345	1310	290	302
13th September	1076	840	251	218
$S.E_D.$	33	39	11	9
C.D.(P=0.05)	69	86	24	21
N_{90}	1118	-	261	-
N_{120}	1286	-	301	-
N_{150}	1412	-	322	-
$S.E_D.$	33	-	11	-
C.D.(P=0.05)	69	-	24	-
P_{18}	-	1112	-	251
P_{22}	-	1372	-	318
$S.E_D.$	-	39	-	9
C.D.(P=0.05)	-	86	-	21
Direct sowing	1292	1204	212	182
20 day	-	1135	-	214
30 day	1312	1186	350	254
45 day	1242	1072	322	206
$S.E_D.$	19	25	7	5
C.D.(P=0.05)	40	51	14	10

Note : Interactions are not significant

Unlike in squaring stage there was a progressive increase in DMP with the N application.

Higher plant population (P_{22}) increased the DMP as the effect of increased number of plants per unit area might have become pronounced.

The 30 day old seedling produced greater dry matter than the direct seeded crops in 1980. It did not differ with the direct seeding as well as the 20 day old seedling and was, however, greater than in the 45 day old, during 1981. Similar trend of the accumulation of total dry matter was observed in the reproductive parts as well.

iii) Maturity stage (Table 12): The pattern of DMP was same as found at the flowering stage in respect of date of sowings and transplantings. The variations in the DMP might be attributed to the effect of weather parameters prevailed from sowing to maturity. Such seasonal effects on DMP was observed by Chamy (1979).

A linear increase in DMP was observed for the each level of N added. The increase might have been contributed by the greater plant height and LAI values. Francis *et al*. (1979) reported similar findings with regard to the effect of N on DMP.

Higher population (P_{22}) increased the DMP over the lower level (P_{18}) as in the flowering stage. The direct sown crops

Table 12. Dry matter production in cotton at maturity (kg/ha)

Treatment	Total		Reproductive parts	
	1980	1981	1980	1981
14th August	5980	6271	2451	2354
29th August	5462	5763	1986	2085
13th September	4515	4612	1665	1656
$S.E_T.$	127	151	53	62
C.D.(P=0.05)	292	237	122	136
N_{90}	4525	-	1815	-
N_{120}	5214	-	2237	-
N_{150}	6218	-	2050	-
$S.E_D.$	127	-	53	-
C.D.(P=0.05)	292	-	122	-
P_{18}	-	5248	-	1940
P_{22}	-	5850	-	2123
$S.E_D.$	-	151	-	62
C.D.(P=0.05)	-	337	-	136
Direct sowing	5761	5829	1723	1800
20 day	-	5570	-	2147
30 day	5480	5554	2328	2200
45 day	4716	5243	2051	1979
$S.E_D.$	66	85	37	41
C.D.(P=0.05)	125	173	75	83

Note : Interactions are not significant

produced more dry matter than the transplanted ones due to greater vegetative growth observed from flowering to maturity.

During 1980, the DMP in the 30 day old seedling was greater than from the 45 day old seedling. In 1981, the 20 and the 30 day old seedlings produced higher dry matter than the 45 day old seedling.

Dry matter accumulation gradually decreased in the reproductive parts as the sowings and transplantings were delayed.

DMP was higher with 120 kg N/ha than with 150 or 90 kg N/ha. The decrease under 150 kg N/ha was due to the increased vegetative growth as is evident from the greater plant height and LAI values.

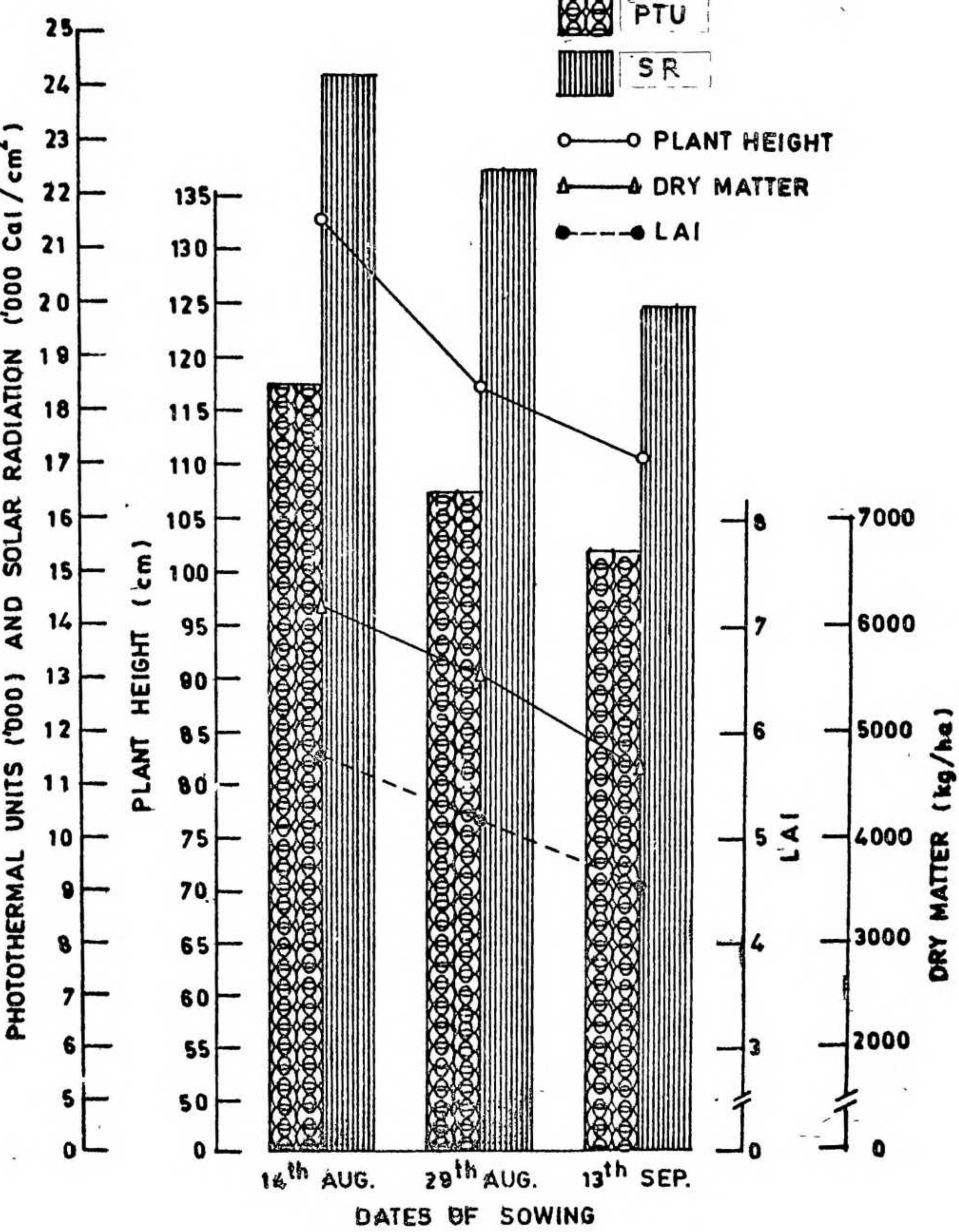
The 30 day old seedling produced higher dry matter in the reproductive parts.

Eventhough, the total DMP was higher in direct seeded crop, the quantity of dry matter accumulated in the reproductive parts was lower than that of the transplanted crops. The cause might be, the increased vegetative growth with inadequate sink capacity.

4.13. Effect of weather parameters on growth components (Fig.2)

The accumulated photothermal units (PTU) and the solar radiation (SR) were taken to study their effect on growth components. Since, the PTU is a product of the day degree and day

FIG.2 EFFECT OF WEATHER PARAMETERS ON GROWTH COMPONENTS



length, it was observed to be more appropriate and accurate than the day degrees alone in studying its effect on plant growth (Huttonson, 1955). Multiple linear regression equations were computed to study the nature and the magnitude of their effect on growth components.

i) Plant height at maturity

$$Y = 0.475 \text{ PTU} + 4.463^{*} \text{ SR} - 0.451 \quad (R^2\ 0.85)$$

Where Y = Plant height, PTU = photothermal units

SR = Solar radiation Cal/cm^2

* = Significant at 5% level

The R^2 value of 0.85 indicates that 85 per cent of the variation in plant height could be accounted for by the weather parameters included. Solar radiation alone contributed to 72.6 per cent of the total variation of 85 per cent.

There was a progressive decrease in plant height in the crops raised at fortnightly intervals from 14th August to 13th September. The reduction in plant height might be due to the decline in PTU and SR values. The reduction in SR and PTU values was due to cloudy weather and drop in day/night temperature, respectively, occurred during the months of October through December. The drop in the SR levels might have reduced the photosynthetic activity, with the consequent reduction in plant height as is evident from the significant positive regression coefficient. Eventhough, the PTU had positive coefficient, its effect was not significant. Dastur (1959) observed that cloudy weather coupled with low temperature reduced the production of carbohydrate in leaves, resulting in reduced plant growth.

The temperature range that prevailed might have been narrow to produce any significant change in the present study. Hesketh and Low (1968) and Hearn (1976) reported that higher temperature under adequate supply of moisture and solar radiation had a positive influence on plant height.

ii) Leaf area index

Multiple regression equation

$$Y = 0.004 \text{ PTU} + 0.041^{*} \text{ SR} - 3.83 \quad (R^2 \; 0.651)$$

Where Y = LAI

Regression coefficients indicated the same trend as observed in the case of the plant height. Increased solar radiation levels promoted the leaf growth and development. The reduction in LAI in the 29th and the 13th September crops could be attributed to the decreased quantum of the SR received in the months from October to December. The PTU exhibited a non significant positive effect under the range prevailed during the crop period. Moursi et al. (1977) observed from their growth chamber studies that leaf area development was influenced by the temperature only during the early stage of the crop growth. On the other hand, they reported that there was no relationship between air temperature and leaf area at later stages.

iii) Dry matter production

Multiple regression equation

$$Y = 9.514 \text{ PTU} + 5.831^{*} \text{ SR} - 373.86 \ (R^2 \ 0.665)$$

Where Y = Dry matter production

The dry matter production was influenced by the SR levels as revealed by the positive and significant regression coefficient. However, PTU had no significant effect on DMP within the temperature ranges prevailed. Greater accumulation of the SR levels might have enhanced the dry matter by increasing the photosynthetic rate in the plants. Higher DMP was observed with the increase in SR levels by Gibbon *et al.* (1970). Thomson (1965), and Moraghan *et al.* (1968) from their studies observed increased DMP in plants only with the higher temperature ranges.

4.14. Yield components and yield

4.14.1. Monopodial branching (Table 13): The monopodial branches are contributors to the vegetative growth and dry matter production in cotton. The 14th August sown and transplanted crops produced more number of monopodia than the 13th Setptember crops and was on par with the 29th August crops. The increased number of monopodia resulted in greater vegetative growth as reflected in plant height and dry matter production.

The N levels did not have any appreciable effect on the number of monopodia as observed by Jaganathan (1979).

The population levels had no positive influence on this character.

Only during 1980, more number of monopodia was observed in the direct seeded crops than the transplanted ones. This resulted in greater vegetative growth and increased dry matter production in the direct sown crop.

4.14.2. Sympodial branching (Table 13): Sympodial branching is reproductive in nature and is considered as an important yield attribute. More number of branches was observed with the 14th August sowing and transplanting than with the 13th September sown and transplanted crops in the year 1980. Progressive reduction in sympodial number was observed as the sowing and transplanting were postponed. The increase in plant height observed in the early sown crops might be responsible for this higher number of sympodia. A similar trend of increased sympodial number was observed by Kamalanathan (1962).

Application of 120 and 150 kg N/ha favourably influenced the sympodial number per plant over 90 kg N/ha. This might be due to the increased plant height observed under higher levels of N.

The population levels had no effect on the number of sympodia per plant.

The direct sown and the transplanted crops did not differ between themselves in 1980, whereas, during 1981, the direct sown crop produced more number of sympodia over the transplanted ones.

4.14.3. Number of fruiting points (Table 13): The number of fruiting points is an index of the yield potential of a crop. Greater number of fruiting points were recorded in the 14th August sown and transplanted crops as compared to the 29th August and the 13th September crops. The higher number is attributable to the increased plant height with more number of sympodial branches. Similar observations were made by Narayanan *et al*. (1967) that early sowings produced more number of fruiting points.

Higher number of fruiting points were observed with the 120 kg N/ha than that with 150 and 90 kg N/ha. This confirmed the known effect of N on fruiting points as reported by Venkitaswamy (1980). The lower level of population (P_{18}) produced more number of fruiting points per plant as compared to the higher level (P_{22}). This might have been due to the reduced competition for the growth factors among the plants under the lower level. The results are in agreement with earlier findings of Krishnaswamy (1979).

Table 13. Number of monopodia, sympodia and fruiting points in cotton

Treatment	Number of monopodia per plant		Number of sympodia per plant		Number of fruiting points per plant	
	1980	1981	1980	1981	1980	1981
14th August	2.5	4.1	30.1	47.0	136.7	144.8
29th August	2.4	3.2	27.7	34.5	120.0	116.7
13th September	1.6	1.8	24.8	24.1	121.2	112.2
$S.E_{D.}$	0.42	0.37	1.6	2.6	4.9	5.0
C.D.(P=0.05)	0.87	0.84	3.6	5.8	10.3	10.2
N_{90}	2.1	-	22.5	-	118.4	-
N_{120}	2.7	-	29.1	-	133.3	-
N_{150}	2.2	-	27.1	-	126.2	-
$S.E_{D.}$	0.42	-	1.6	-	4.9	-
C.D.(P=0.05)	N.S.	-	3.6	-	10.3	-
P_{18}	-	3.3	-	37.8	-	129.5
P_{22}	-	2.8	-	32.9	-	119.0
$S.E_{D.}$	-	0.3	-	2.6	-	5.0
C.D.(P=0.05)	-	N.S.	-	N.S.	-	10.2
Direct sowing	2.7	3.3	27.8	39.2	130.9	136.5
20 day	-	3.2	-	33.9	-	121.3
30 day	2.0	2.7	26.8	33.4	127.4	124.5
45 day	2.1	2.8	27.9	34.9	119.8	115.8
$S.E_{D.}$	0.19	0.32	1.2	1.5	4.8	5.2
C.D.(P=0.05)	0.32	N.S.	N.S.	3.5	10.3	10.5

Note : Interactions are not significant
N.S. : Not significant

In both the cropping seasons, the direct seeded crops produced higher number of fruiting points than the 45 day old seedling. The cause might be due to the increased plant height with more number of sympodia.

4.14.4. <u>Number of bolls per plant</u> (Table 14) : In both the cropping seasons, progressive decrease in boll number per plant was recorded for the successive delay in sowing dates. This might be due to the ability of the plants to retain more number of bolls, complemented by the favourable weather conditions that prevailed during the boll maturation period of the early sown crops. Under late sown conditions low boll number due to poor boll set was observed. Similar observations were made by Dastur (1959), Srisook <u>et al</u>. (1975).

Greater number of bolls per plant was recorded with the application of 120 kg N/ha over 150 and 90 kg N/ha. Eventhough, the number of fruiting points under 150 kg N/ha was comparable with the 120 kg N/ha, there was a reduction in boll number owing to greater shedding of squares and bolls. Excessive shedding might have been favoured by higher LAI values as observed by Constable and Gleeson (1977).

A significant reduction in boll number with the higher population level (P_{22}) was observed. The reason might be the excessive competition for the growth factors, resulting in lesser initiation of squares.

In both the cropping seasons, the 30 day old seedling retained more number of bolls per plant than the 45 old seedling and the direct sown crop. In 1981, the number of bolls with the 20 day old seedling was superior to that from the 45 day old seedling and the direct sown and was, however, on par with the 30 day old seedling. The greater number of bolls with the 30 day old seedling could be attributed to the presence of optimum LAI values for photosynthesis.

4.14.5. Boll weight (Table 14): The boll weight did not differ between the 14th and 29th August sowings and transplantings. On the other hand, the crops sown and transplanted on 13th September produced heavier bolls. The reason might be the presence of lesser number of bolls in the late crops, sharing the total photosynthates produced. Similar observations were made by Fowler and Ray (1977). The influence of weather parameters on boll weight was also pointed out by Christidis and Harrison (1955) and Dastur (1959).

The influence of N on boll weight was meagre both in the direct seeded and the transplanted crops. Similar non-significant effect of N on boll weight was observed by Damodaran (1975) and El-Debaby (1977).

Lower population (P_{18}) produced heavier bolls. This might be due to the greater availability of photosynthates to the developing bolls as observed by Fowler and Ray (1977).

The boll weight did not differ between the direct sown and the transplanted crops. Different ages of seedlings also had no effect on boll weight.

4.14.6. <u>Setting per cent</u> (Table 14): In 1980, a progressive decrease in setting per cent of bolls for the delay in sowing and transplanting from 14th August onwards was observed. However, in 1981, it did not differ with the 14th and the 29th August sown and transplanted crops. The lower boll set in late sown crops might be due to the higher shedding of young floral parts. The inclement weather with higher per cent of relative humidity and reduced solar radiation levels prevailed during the months of November and December might have favoured increased shedding. Guinn (1974) observed that cloudy weather even for a period of four days increased the shedding of floral parts.

The setting per cent was higher for the application of 120 kg N/ha over 90 and 150 kg N/ha. Excessive shedding due to higher LAI values might be the reason for the low boll set that occurred under 150 kg N/ha.

The lower population level (P_{18}) recorded higher per cent of boll setting as compared to the higher level (P_{22}) on account of lesser competition for growth factors.

The thirty day old seedling registered higher per cent of setting than the 45 day old seedling and the direct seeding.

Table 14. Number of bolls, boll weight and setting per cent in cotton

Treatment	Number of bolls per plant		Boll weight (g)		Setting (per cent)	
	1980	1981	1980	1981	1980	1981
14th August	43.1	34.7	3.29	3.52	31.5	24.0
29th August	34.2	26.1	3.36	3.95	28.5	22.3
13th September	24.1	21.2	3.89	4.15	19.8	18.8
$S.E_{D.}$	3.2	1.9	0.18	0.22	1.1	0.81
C.D.(P=0.05)	6.6	4.2	0.40	0.49	2.5	1.66
N_{90}	30.6	-	3.61	-	25.8	-
N_{120}	38.5	-	3.36	-	28.8	-
N_{150}	32.3	-	3.57	-	25.5	-
$S.E_{D.}$	3.2	-	0.18	-	1.1	-
C.D.(P=0.05)	6.6	-	N.S.	-	2.5	-
P_{18}	-	30.0	-	4.20	-	23.1
P_{22}	-	24.2	-	3.57	-	20.3
$S.E_{D.}$	-	1.9	-	0.22	-	0.81
C.D.(P=0.05)	-	4.2	-	0.49	-	1.66
Direct sowing	30.4	25.0	3.57	3.90	24.3	18.3
20 day	-	27.5	-	3.87	-	22.6
30 day	39.6	29.5	3.45	3.81	31.0	23.6
45 day	31.4	24.4	3.52	3.88	24.5	21.0
$S.E_{D.}$	2.9	1.3	0.18	0.16	0.90	0.59
C.D.(P=0.05)	5.9	2.6	N.S.	N.S.	1.81	1.24

Note : Interactions are significant
N.S. : Not significant

In 1981, the setting per cent with the 20 day old seedling was superior to the 45 day old seedling and the direct sowing and was on par with the 30 day old seedling. The superiority of the 30 day old seedling might be due to the presence of optimum LAI values, favouring adequate nourishment of the developing bolls.

4.14.7. Fruiting coefficient (Table 15): Fruiting coefficient denotes the ratio of seed cotton yield to total dry matter produced by the plant. In 1980, the fruiting coefficient showed a progressive decrease as the sowings and the transplantings were delayed from 14th August. During 1981, the 14th August sowing and transplanting were superior to the other dates. The early sown crops had conducive weather conditions like increased solar radiation for the production of enough photosynthates and translocation to a greater extent to the reproductive organs.

The fruiting coefficient was high under 90 kg N/ha followed by 120 and 150 kg N/ha. The lowest value under 150 kg N/ha was due to reduced seed cotton yield as compared to total DMP. A greater proportion of assimilates might have been directed towards the vegetative growth as opined by Fowler and Ray (1977).

The fruiting coefficient was higher at lower population (P_{18}) level owing to better vegetative growth using the major share of carbohydrates.

Increased fruiting coefficients were observed with the 30 day old seedling over the direct seeded crop. Eventhough, the total dry matter produced was lesser than direct seeded crop, more conversion of carbohydrates into bolls occurred, which increased the fruiting coefficient against the direct sown crop. It is evident from the results that the transplanted crops are more efficient in diverting more of photosynthates in to the bolls with restricted vegetative growth.

4.15. Seed cotton yield (Table 15 and 16):

In both the cropping seasons, a progressive decrease in the yield of seed cotton for the successive delay in the sowings and transplantings beyond 14th August was observed. A reduction of about 9 q/ha in seed cotton yield was observed with the 13th September crops as compared to the 14th August crops. The decrease could be attributed to the reduction in boll number. In addition, the reduction in plant height, LAI values, sympodial branches, boll set and boll number were the major contributing factors for lower yield in the late sown and transplanted crops. These factors were prone to the influence of weather parameters prevailed during the growth periods. The results of the present study confirmed the earlier findings of Chamy and Balasubramaniam (1976). They observed that under Coimbatore conditions, sowing the winter cotton beyond the first fortnight of August, resulted in considerable reduction in seed cotton yield.

Table 15. Fruiting coefficient and seed cotton yield

Treatment	Fruiting coefficient		Seed cotton yield (q/ha)	
	1980	1981	1980	1981
14th August	0.636	0.506	36.84	31.78
29th August	0.616	0.490	31.18	26.19
13th September	0.553	0.454	27.74	22.62
$S.E_{D.}$	0.29	0.21	0.95	1.21
C.D.(P=0.05)	0.60	0.48	2.11	2.57
N_{90}	0.692	-	31.33	-
N_{120}	0.642	-	33.65	-
N_{150}	0.469	-	30.94	-
$S.E_{D.}$	0.29	-	0.95	-
C.D.(P=0.05)	0.60	-	2.11	-
P_{18}	-	0.523	-	25.06
P_{22}	-	0.443	-	28.64
$S.E_{D.}$	-	0.21	-	1.21
C.D.(P=0.05)	-	0.48	-	2.57
Direct sowing	0.527	0.420	30.41	24.53
20 day	-	0.489	-	27.29
30 day	0.630	0.541	34.97	30.08
45 day	0.649	0.486	30.20	25.53
$S.E_{D.}$	0.17	0.146	0.58	1.18
C.D.(P=0.05)	0.34	0.282	1.20	2.39

Note : Interactions between Dates of sowing, nitrogen and population levels are significant only with seed cotton yield.

Application of N at 120 kg/ha increased the yield of seed cotton over 90 kg N/ha and was on par with 150 kg N/ha. The increase could be attributed to the higher boll number with 120 kg N/ha. The results are in agreement with those reported by Koraddi *et al.* (1980) that the optimum dose for Varalakshmi was 120 kg N/ha. The absence of response to the higher level could be attributed to the rank vegetative growth and the high LAI values which resulted in low boll number per plant.

Interaction effect between dates of sowings and nitrogen levels was observed. Under the 14th August sowing and transplanting, 120 kg N/ha produced higher seed cotton over 90 kg N/ha and was on par with 150 kg N/ha. On the other hand, in 29th August sowing and transplanting, the yield at 90 kg N/ha was found on par with 120 kg and 150 kg N/ha. In the 13th September sowing and transplanting, the response for the higher doses was very poor. The results indicated that for the early sown or transplanted crop, application of 120 kg N/ha was optimum for economical yield. The higher dose did not further increase the yield over 120 kg N/ha. Under late sown conditions, application of 90 kg N/ha appeared to be more economical. The increased response in the early sowing for the applied N was probably due to the conducive weather conditions prevailed, which promoted optimum growth with increased number of bolls. Studies at Coimbatore revealed that the yield differences due

Table 16. Interaction table for seed cotton yield (q/ha)

Year	1980				1981		
Treatment	N_{90}	N_{120}	N_{150}	Mean	P_{18}	P_{22}	Mean
14th August	34.34	38.18	38.00	36.84	31.34	32.15	31.78
29th August	30.90	33.50	27.15	30.18	23.75	28.63	26.19
13th September	28.76	29.29	27.69	28.74	20.10	25.14	22.62
Mean	31.33	33.65	30.94		25.06	28.64	

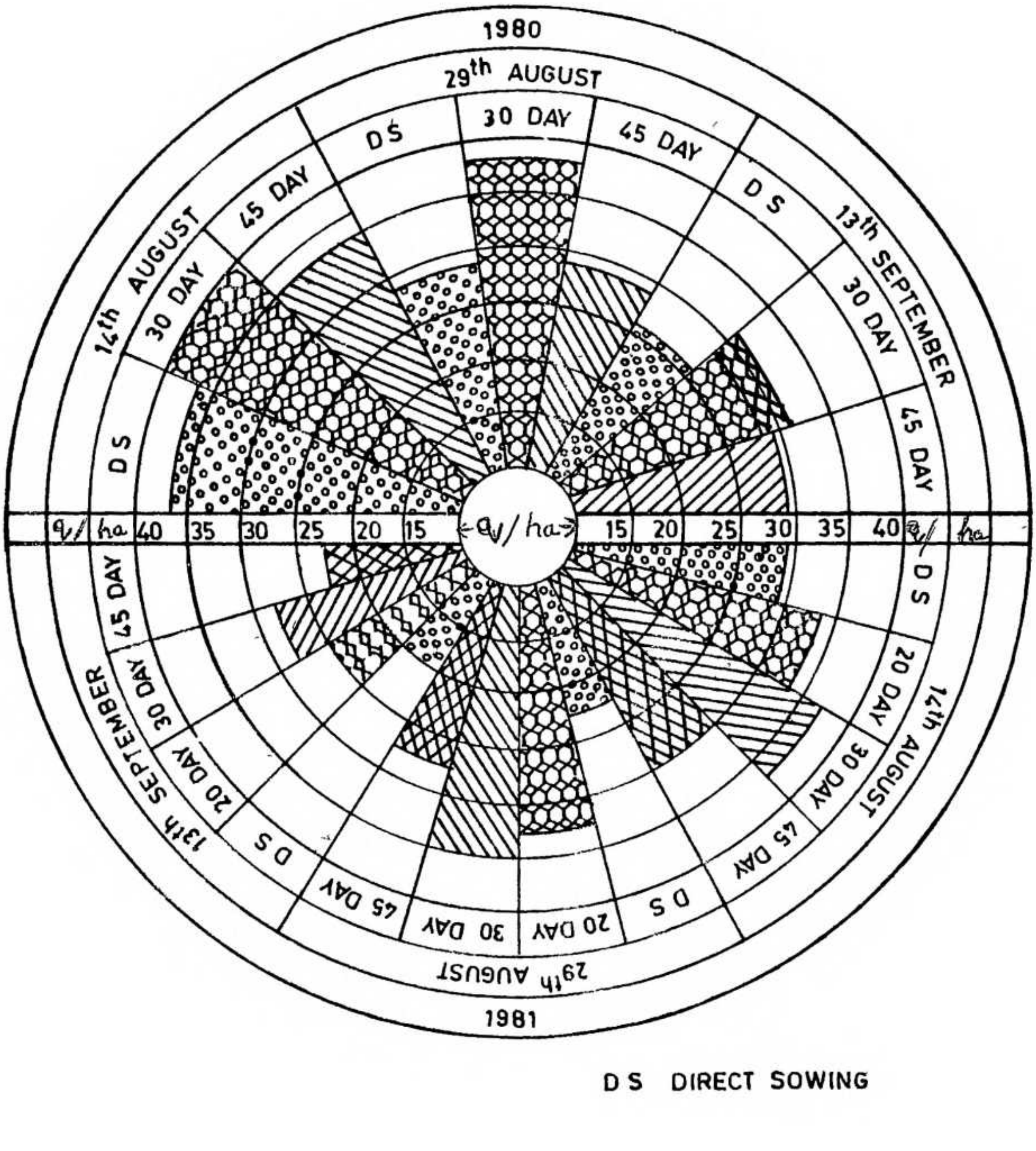
	1980		1981	
	$S.E_D.$	C.D.(P=0.05)	$S.E_D.$	C.D.(P=0.05)
	1.68	3.56	1.48	3.29

to the N application pronounced significant only with early sown crops (Anon. 1973). Similar observations that early sowings responded better for the applied N were made by Burhan and Jackson (1973).

The higher propulation level (P_{22}) resulted in increased yield over the lower level (P_{18}) on account of increased number of plants per unit area. The interaction effect with sowing dates was observed. Increasing the population over the currently recommended level (P_{18}) did not result in higher yields in the 14th August sowing and transplanting. On the other hand, the higher level (P_{22}) produced increased yield in the 29th August and the 13th September sown and transplanted crops. The superiority in the yield components with the individual plants under the lower population did not compensate the increase in plant number per unit area with the higher population, especially under late sown and transplanted conditions. Similar observations were made by Kanniyan and Balasubramanian (1952) and Galonopoulou ét al..(1980)

In 1980, the 30 day old seedling excelled the direct sown crop and the 45 day old seedling in seed cotton yield. During 1981, the 20 and 30 day old seedlings yielded more than the direct sown and the 45 day old seedling, eventhough, they did not differ among themselves. The yield increases recorded in 1980, with the 30 day old seedling over the respective direct sown crops were 3.34, 8.09 and 5.41 q/ha, respectively,

FIG 3 SEED COTTON YIELD
DATES OF SOWING AND AGES OF SEEDLING



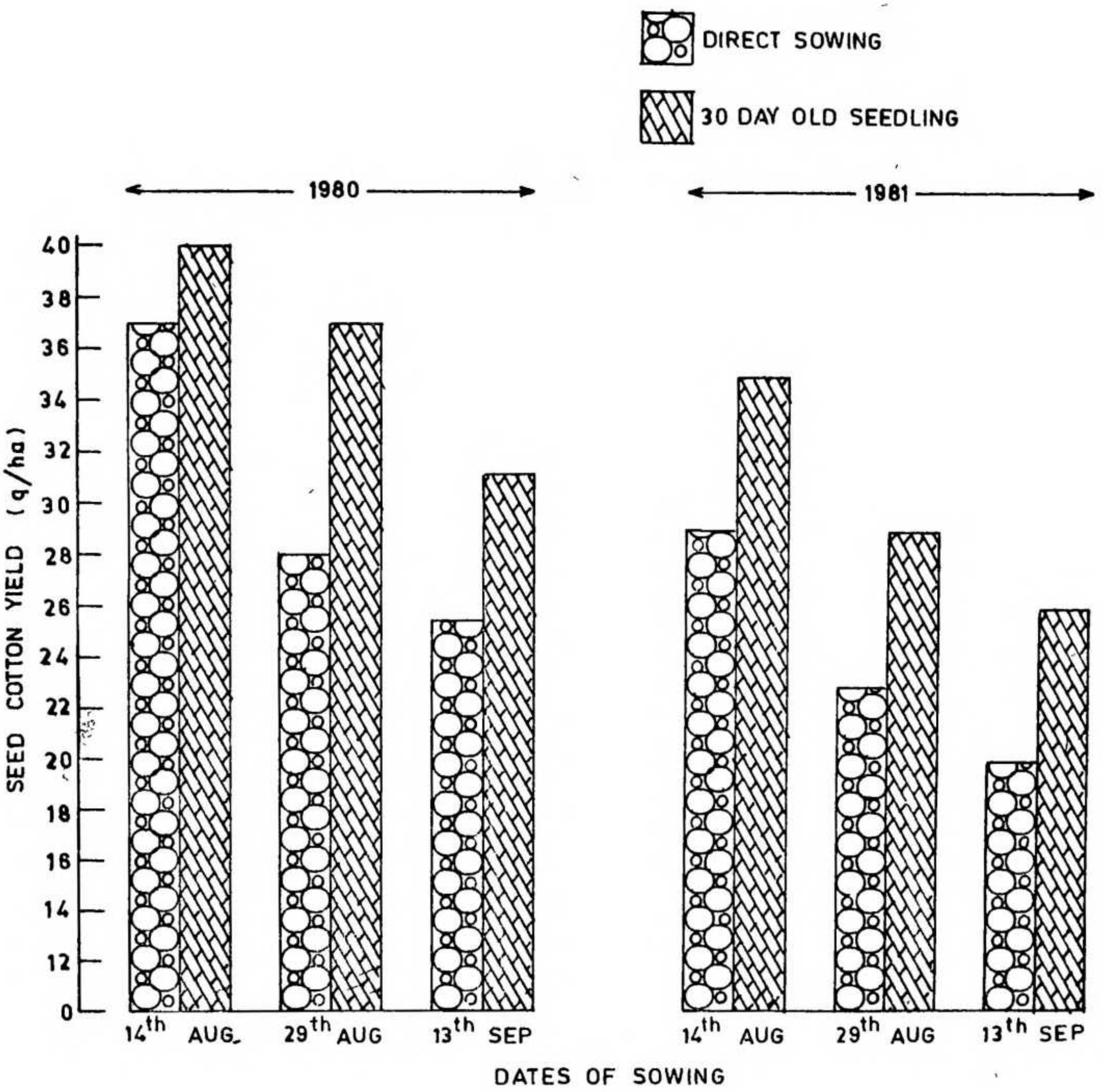
D S DIRECT SOWING

for the 14th August, the 29th August and the 13th September transplantings. During the year 1981, the increases were 7.51, 6.18 and 5.87 q/ha with the 30 day old seedling and 5.86, 3.91 and 3.97 q/ha with the 20 day old seedling respectively, for the three dates of transplantings against their respective direct seeded crops (Fig. 3).

In both the years, the seed cotton yield from the 30 day old seedling raised on 31st July and transplanted on 29th August was comparable with that from the direct seeded crops, sown on 14th August. Similarly raising nursery on 14th August and transplanting on 13th September resulted in enhanced seed cotton yield by 2.31 and 2.87 q/ha, respectively, during 1980 and '81 as compared to the 29th August direct seeded crops.

In both the cropping seasons, the 30 day old seedlings produced increased yield. The magnitude of increase was greater especially under late sown conditions against their respective direct seeded crops (Fig.4). Thus, the results of the present study brings out the superiority of transplanting over the direct seeding. If the fields are available during the early periods in the season, raising the seedlings in advance and transplanting after 30 days would result in increased yield. In case, the fields are occupied by the previous crops till late in the season, transplanting is more advantageous over the late sown direct seeded crop. In the water secarcity areas, sowings in larger areas cannot be taken at a stretch

FIG 4 SEED COTTON YIELD
DIRECT SOWING AND 30 DAY OLD SEEDLING



and establish the crop. Under such contingencies nurseries can be raised at intervals and the seedlings transplanted in a phased manner. Therefore, the probable yield losses in the late sown crops could be made good to a greater extent by raising the *pai* nurseries in advance and transplanting the seedlings late in the season.

4.16. Effect of weather parameters on yield components and yield (Fig.5)

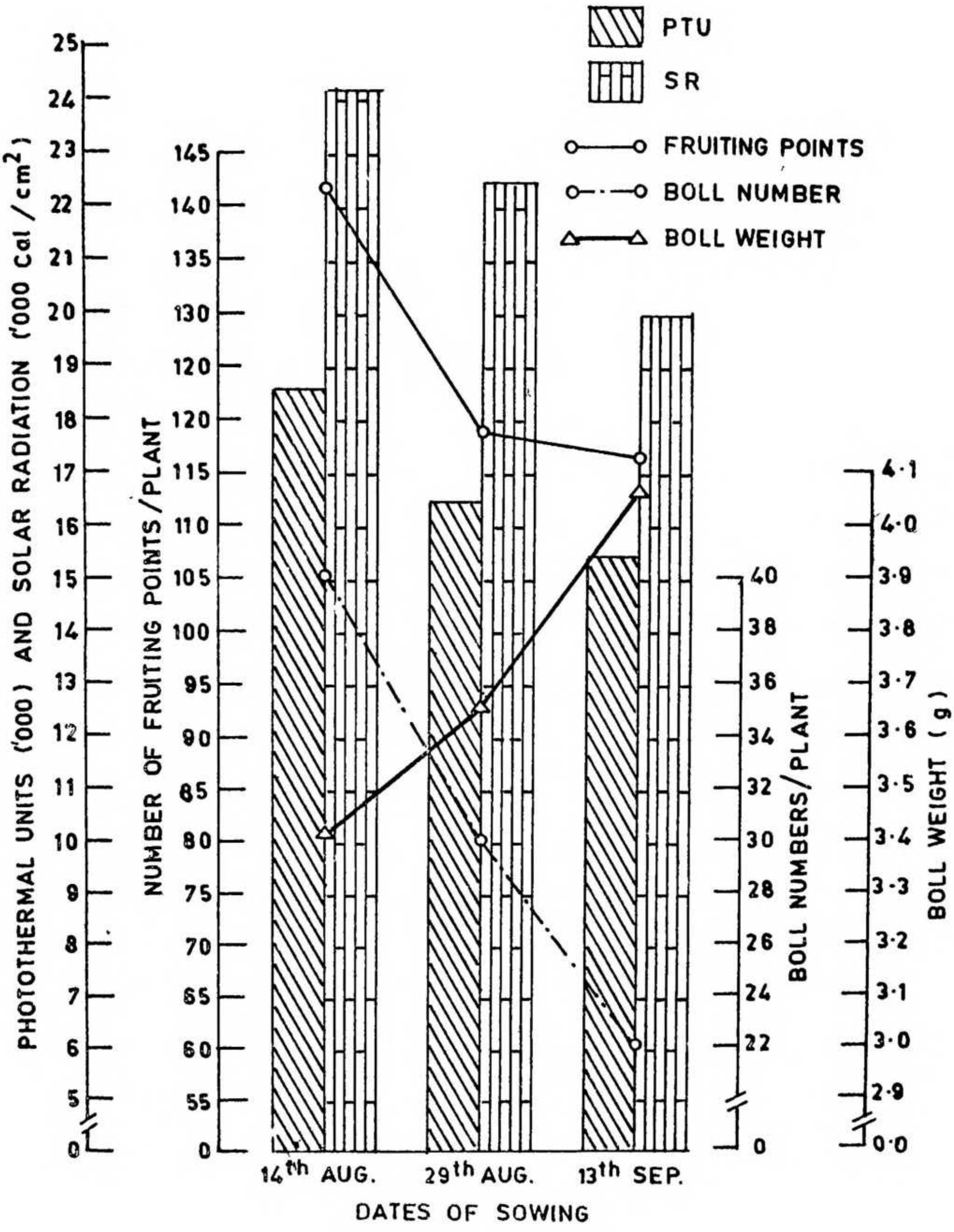
1) Boll number per plant: The accumulated PTU and SR values were recorded from the date of first flower to maturity for each sowing to study their effect on the boll number.

Multiple regression equation

$$Y = 0.59\ PTU + 4.24^{*}\ SR - 48.99\ (R^2\ 0.85)$$

Out of 85 per cent of total variation in boll number indicated by the R^2 value, 76.9 per cent was contributed by solar radiation. In the 14th August sowing more number of bolls produced might be due to more amount of solar energy received over a longer boll maturation period. At the optimum SR levels, there would have been a concurrent production of sympodial branches with new squares. There was a gradual reduction in the accumulated SR levels with the late sown crops, limiting the production of new sympodial branches. Added to this, there would have been a decrease in photosynthetic activity of the plants. This might have increased the shedding of floral parts owing to the nutritional imbalances, as pointed out by Guinn (1974).

FIG.5 EFFECT OF WEATHER PARAMETERS ON YIELD COMPONENTS



The accumulated PTU, however, had no significant effect on the boll number. The temperature differences might have been smaller to produce any distinct effect. Ehlig and Lemert (1973) observed that there was no relationship between boll retention and maximum and minimum temperatures.

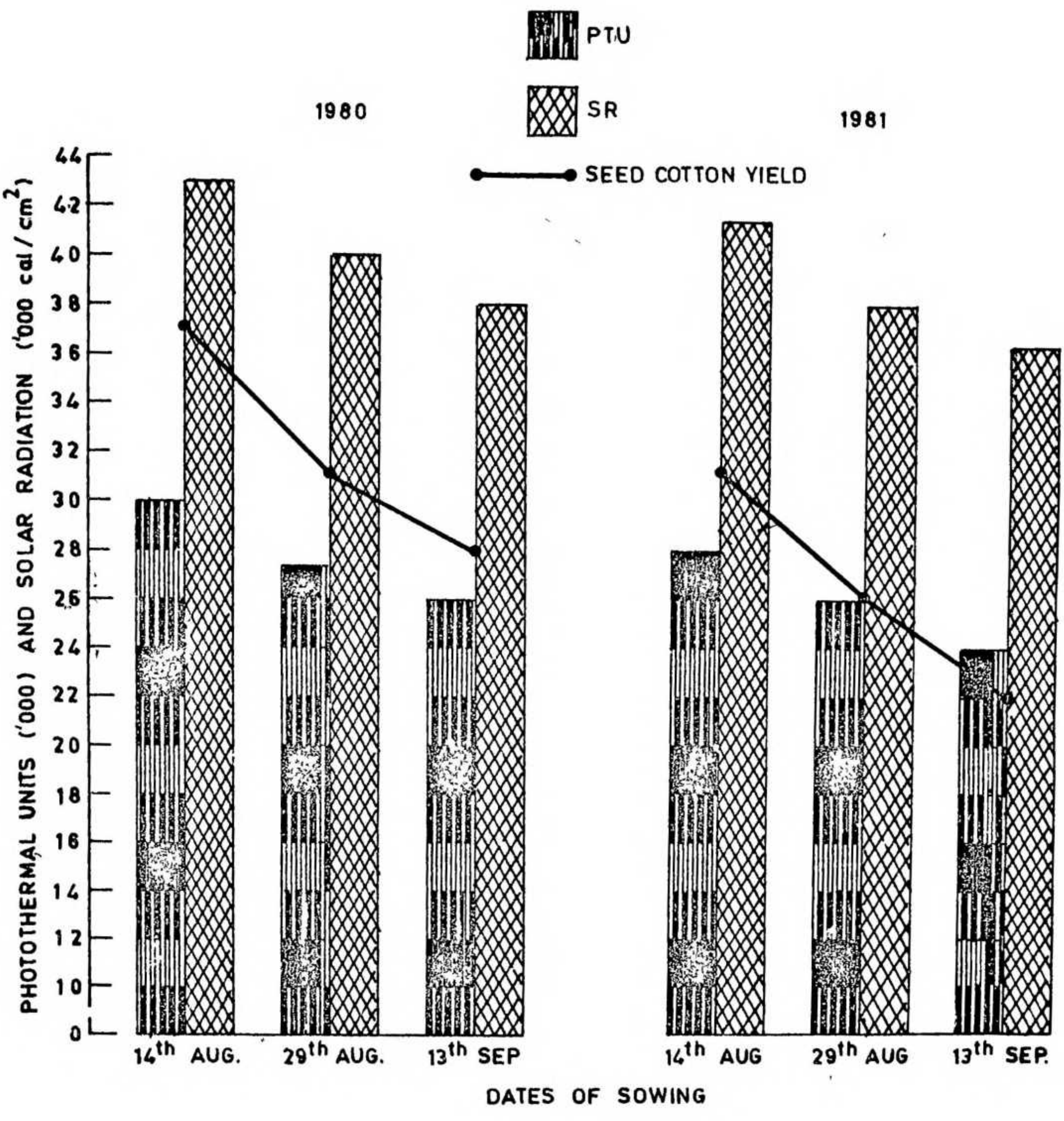
ii) Seed cotton yield (Fig.6) : The accumulated PTU and SR values for the total crop period were taken.

$$Y = 0.445 \text{ PTU} + 2.\overset{*}{8}1 \text{ SR} - 95.500 \ (R^2 \ 0.848)$$

Eighty five per cent of the total variations in the seed cotton yield was governed by the PTU and SR levels during the crop period. Out of this, 74 per cent was accounted for by the SR levels received during the cropping period as brought-out by the significant regression coefficient.

A gradual reduction in PTU values for the crops sown from 14th August to 13th September was observed. For getting about 30 q/ha of seed cotton an accumulated PTU of 27,000 (2,500 growing degree days) and SR of 40,000 Cal cm^{-2} (222 Cal cm^{-2} day^{-1}) would be required under Coimbatore condition. Similar models with growing degree days computed by Memhan and Low (1972) revealed that it was possible to obtain 3000 kg of seed cotton/ha with 2230 growing degree days, if the average level of solar radiation was 580 Cal cm^{-2} day^{-1} for a crop sown in October and harvested in May.

FIG.6 EFFECT OF WEATHER PARAMETERS ON SEED COTTON YIELD



4.17. Quality characters

4.17.1. Ginning percentage (Table 17) : The date of sowing and transplanting had no influence on the ginning per cent in both the cropping seasons. The results are in agreement with those observed by Abrham *et al.* (1980).

Application of different doses of N did not have any effect on ginning per cent. Similar observations were made by Wankhede and Sadapal (1977).

The ginning per cent did not differ between higher population (P_{22}) and lower level (P_{18}). The results are in line with those reported by Buxton *et al.* (1977).

The results of the present study indicated that ginning per cent was not altered due to the transplanting with different ages of seedlings. Similar observations were made by Bodade (1965).

4.17.2. Lint index (Table 17) : Much variations were not observed in lint index for the shifts in the date of sowings and transplantings. Misra and Malik (1979) reported that sowing seasons had no effect on lint index.

Lint index was not influenced by the levels of N in both the cropping seasons. Chamy (1979) reported that there was no influence of N on lint index in CBS 156 cotton.

Table 17. Ginning per cent, lint index and seed index in cotton

Treatment	Ginning per cent		Lint index		Seed index	
	1980	1981	1980	1981	1980	1981
14th August	32.2	32.9	4.7	4.9	9.4	9.8
29th August	32.1	32.5	4.5	4.3	9.5	9.8
13th September	32.5	31.9	4.6	4.7	9.5	9.9
$S.E_D.$	0.31	0.43	0.35	0.42	0.21	0.49
C.D.(P=0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
N_{90}	32.0	-	4.7	-	9.1	-
N_{120}	32.4	-	4.6	-	9.4	-
N_{150}	32.2	-	4.6	-	9.8	-
$S.E_D.$	0.31	-	0.35	-	0.21	-
C.D.(P=0.05)	N.S.	-	N.S.	-	0.46	-
P_{18}	-	32.5	-	4.7	-	9.8
P_{22}	-	32.4	-	4.5	-	9.8
$S.E_D.$	-	0.43	-	0.42	-	0.49
C.D.(P=0.05)	-	N.S.	-	N.S.	-	N.S.
Direct sowing	32.2	32.4	4.4	4.6	9.4	9.8
20 day	-	32.4	-	4.7	-	9.9
30 day	32.1	32.5	4.8	4.7	9.4	9.8
45 day	32.4	32.4	4.7	4.5	9.5	9.8
$S.E_D.$	0.21	0.29	0.21	0.32	0.16	0.41
C.D.(P=0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Note : Interactions are not significant
N.S. : Not significant

Population levels did not cause any variation in lint index as reported by Wankhede and Sadapal (1977).

The transplanted crops with different ages of seedlings did not differ in lint index in both the seasons. The results are in line with the earlier findings of Krishnadoss et al. (1979) that transplanted crop of Varalakshmi did not differ in lint index with direct sown crops under rainfed conditions.

4.17.3. Seed index (Table 17): Different dates of sowing and transplanting did not cause any variation in seed index. Such a non-significant effect of sowing dates was also observed by Sivakumar (1977).

Application of 150 kg N/ha had a positive influence on seed index over 90 and 120 kg N/ha. Ali and Chandramohan (1974) observed an increase in the seed index for the application of 60 kg N/ha with the variety MCU 1.

Population levels had no distinct effect on seed index. The results are in agreement with earlier findings of Krishnaswamy (1979).

No variations were observed with different ages of seedlings transplanted in respect of the seed index.

4.17.4. Mean fibre length (Table 18): Mean fibre length was superior with the 14th August sowing and transplanting in both the cropping seasons. The results are in agreement with that of Abrham *et al.* (1980). They observed that early sowings favoured the fibre length in the cultivar, Varalakshmi.

Nitrogen levels had no distinct effect on the mean fibre length. Similar non-significant effect was reported by Shalaby *et al.* (1977).

The two population levels did not show any variation in mean fibre length as observed by Baker (1976).

The transplanted crops were superior in mean fibre length to the direct seeded crops. Improvement in fibre length with transplanted crops was observed by Bodade (1965).

4.17.5. Maturity coefficient (Table 18): The date of sowing or transplanting had no influence on maturity coefficient. The results are in agreement with the earlier observations of Misra and Malik (1979).

Maturity coefficient was not influenced by the levels of nitrogen tried in the present study.

Population levels did not cause any distinct variation in this character. Similar effect of population was observed by Baker (1976).

The results of the present study revealed a non-significant effect of transplanting on this character.

Table 18. Mean fibre length, maturity coefficient, fibre fineness and bundle strength in cotton

Treatment	Mean fibre length(mm)		Maturity coefficient		Fibre fineness		Bundle strength	
	1980	1981	1980	1981	1980	1981	1980	1981
14th August	30.6	28.9	0.66	0.65	2.9	2.8	8.6	8.9
29th August	29.4	28.6	0.66	0.64	2.9	2.8	8.8	8.8
13th September	28.9	27.8	0.64	0.66	2.7	2.8	8.8	8.7
S.E.D.	0.28	0.26	0.12	0.26	0.19	0.15	0.20	0.26
C.D. (P=0.05)	0.60	0.53	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
N_{90}	29.1	-	0.66	-	2.9	-	8.7	-
N_{120}	29.5	-	0.64	-	2.9	-	8.8	-
N_{150}	30.4	-	0.66	-	2.8	-	8.7	-
S.E.D.	0.28	-	0.12	-	0.19	-	0.20	-
C.D. (P=0.05)	N.S.	-	N.S.	-	N.S.	-	N.S.	-
P_{18}	-	28.6	-	0.63	-	2.8	-	8.7
P_{22}	-	28.2	-	0.67	-	2.8	-	8.9
S.E.D.	-	0.26	-	0.26	-	0.15	-	0.26
C.D. (P=0.05)	-	N.S.	-	N.S.	-	N.S.	-	N.S.
Direct sowing	29.0	28.0	0.66	0.65	2.9	2.8	8.8	8.8
20 day	-	28.6	-	0.64	-	2.8	-	8.7
30 day	30.8	28.8	0.65	0.66	2.9	2.8	8.6	8.8
45 day	29.8	28.0	0.65	0.63	2.8	2.8	8.7	8.8
S.E.D.	0.25	0.15	0.07	0.19	0.11	0.09	0.12	0.12
C.D. (P=0.05)	0.51	0.30	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Note : Interactions are significant
N.S. : Not significant

4.17.6. Fibre fineness (Table 18): The fibre fineness was not affected by the dates of sowing and transplanting. The results are in confirmity with the earlier findings of Kanniyan and Balasubramanian (1952) and Misra and Malik (1979).

Levels of N tried did not have any influence on this character as observed by Chamy (1979).

The two levels of population compared in the present study failed to produce any effect on the fibre fineness. As found in the present study, Baker (1976) observed a non-significant effect.

The crops transplanted with different ages of seedlings had no effect on the fibre fineness.

4.17.7. Bundle strength (Table 18): The dates of sowing and transplanting had no influence on the bundle strength. Abrham *et al*. (1980) found that the sowing dates had no effect on bundle strength. Neither the nitrogen doses nor the population levels affected the bundle strength in the present study. The results are in confirmity with the earlier observations of Jaganathan (1979) and Baker (1976) in respect of N and population levels, respectively.

4.18. Crop duration

4.18.1. Number of days to flower (Table 19): The crops sown and transplanted at fortnightly intervals from 14th August did not differ in the time required for flower initiation. The magnitude of variation in the climatic factors might have been small to effect any change in the duration. In the present study, the correlation between the accumulated PTU (r=0.433) and SR levels (r=0.408) with the days lapsed for flower initiation was found to be non-significant, indicating the absence of the effect of the weather elements. Chamy (1979) did not observe any difference in respect of flower initiation period in the crops raised under the two contrasting seasons of winter and summer.

The nitrogen levels had no effect on the duration of flower initiation.

In both the years, the population levels exerted no influence on the flower initiation period of the direct seeded and the transplanted crops.

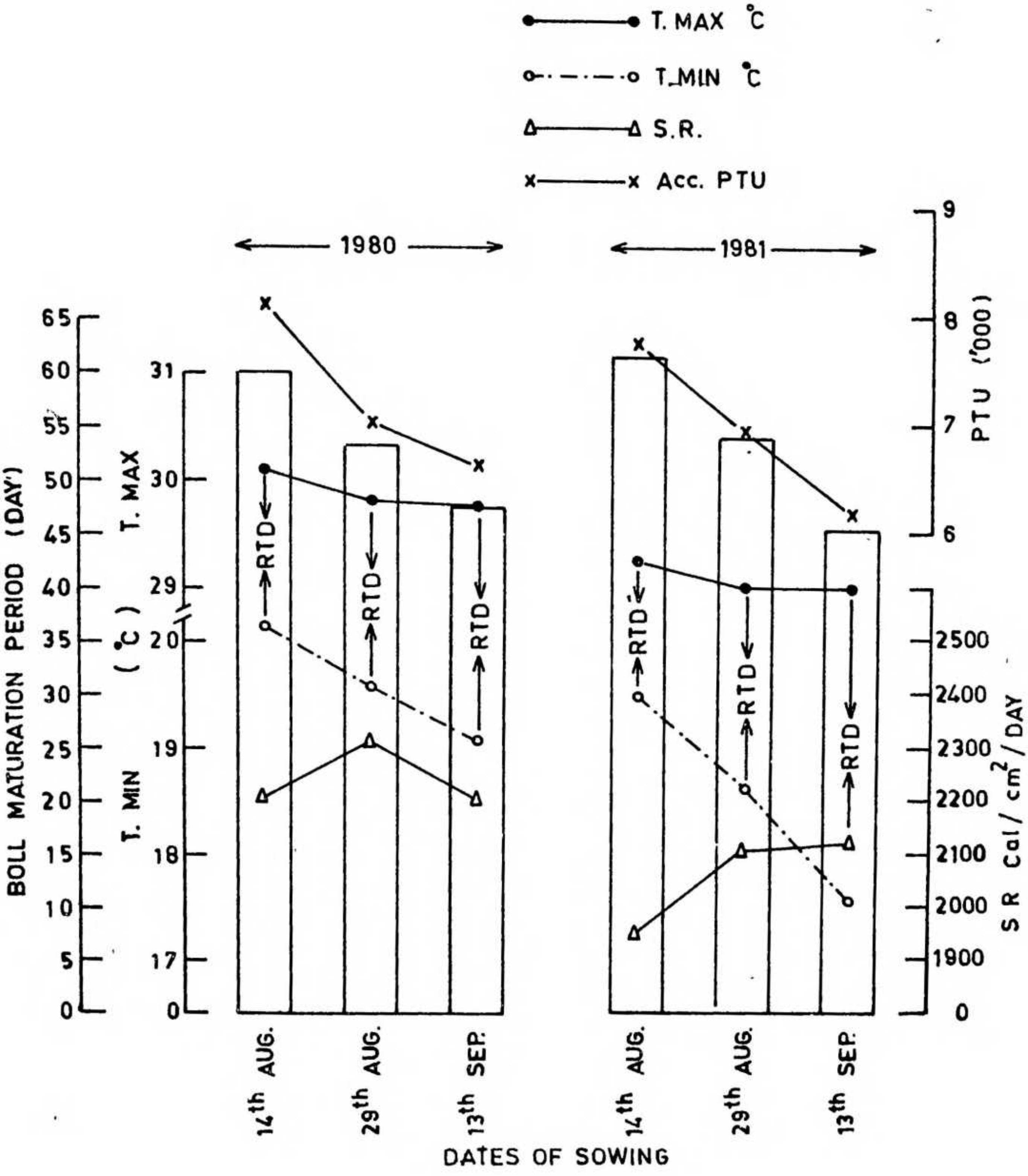
The direct seeded crop took 10 and 13 days more to produce the first flower as against the 30 and 45 day old seedlings, respectively. However, the difference with the 20 day old seedling was only four days. The earliness in the transplanted crop was attributable to the early shift from the vegetative phase to the flowering phase, forced by the physiological ageing of the seedlings. Similar reductions were observed by Arunachalam and Ramanujam (1981). They also found that the magnitude of decrease was proportional to the age of seedlings at transplanting.

4.18.2. Number of days to open boll stage (Table 19): The direct seeded and the transplanted crops of 14th August required more number of days to attain the open boll stage than those raised on 29th and 13th September. However, the difference was narrow between the later crops. Even though, the flower initiation period did not differ among the date of sowings, the number of days required for the boll development was more with the 14th August crops. The shorter boll maturation period with late sown crops might have been due to the drop in night temperature during the months of December and early January (Fig.7). This increased the relative temperature disparity (RTD) which might have hastened the maturity of bolls. In the present study a significant positive correlation was observed between the accumulated PTU (0.848), SR levels (0.660) and boll maturation periods. Young et al., (1980) observed that decreasing night temperature increased the effect of heat degree units. They further reported that the delayed sowings had a diminished accumulation of day degrees with the shortened boll maturation period.

The duration from sowing to the open boll stage was not affected by the nitrogen levels.

The population levels had no influence on the time required to attain the open boll stage.

FIG.7 EFFECT OF WEATHER DURING BOLL MATURATION PERIOD



4.18.3. <u>Total field duration</u> (Fig.8): In both the cropping seasons, there was a reduction in field duration by about a week in the 29th August and the 13th September sown and transplanted crops as against the 14th August crop. In the present study, the total duration of the crop was influenced by the weather parameters, as revealed by positive correlation coefficients with PTU (0.585) and SR values (0.822). In the year 1980, the total reduction with the 30 day old seedling was 10 - 15 days and in the case of 45 day old seedling, the range was 15 - 20 days as against their respective direct sowings under different dates. During 1981, the reduction was 5-7 days with 20 day old seedling, 10 - 17 days in 30 day old seedling and 17-24 days under the 45 day old seedling.

The results revealed that there was an overall saving in field duration by about 2 weeks with the 30 day old seedling and 3 weeks with the 45 day old seedling. Similar reductions in the field duration with the transplanted crops were observed by Arunachalam and Ramanujam (1981).

4.18.4. <u>Per cent of seed cotton harvested at 150th day</u> (Table 19): The duration of the crop has to be limited to the extent when the maximum yield is obtained before releasing the field for the subsequent crop. The effective earliness index can only be based on the production of seed cotton at the particular period in the picking phase.

FIG. 8 FIELD DURATION (DAY)

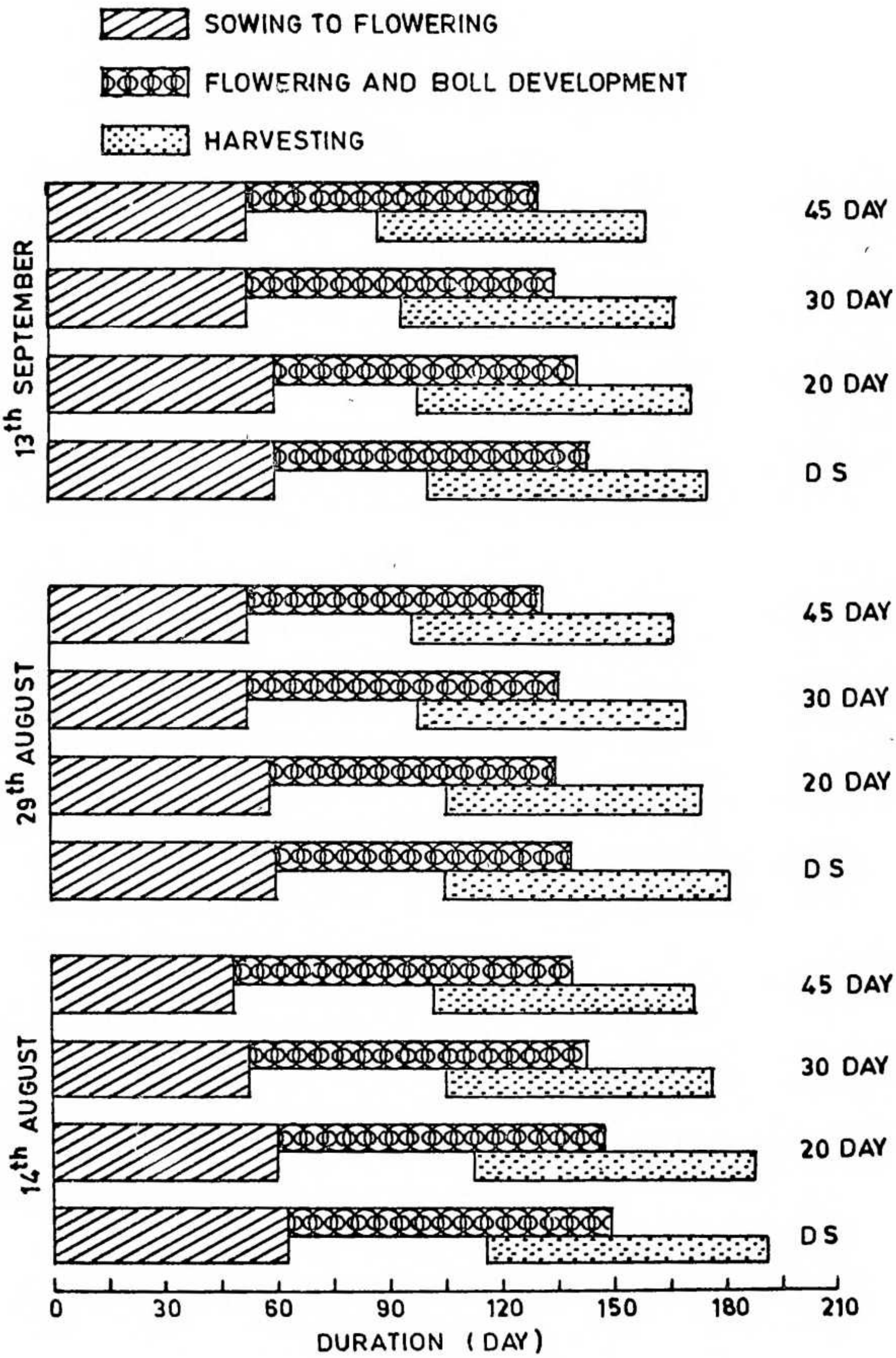


Table 19. Number of days to flower, boll opening and seed cotton yield at 150th day

Treatment	Days to flower		Days to open boll		Seed cotton yield at 150th day (per cent to total)	
	1980	1981	1980	1981	1980	1981
14th August	56.8	55.2	105.7	110.6	52.7	45.2
29th August	59.8	57.5	98.5	103.2	60.5	50.7
13th September	54.6	53.7	95.2	99.1	68.0	56.9
S.E$_D$.	2.62	1.95	2.0	2.9	2.3	2.0
C.D.(P=0.05)	N.S.	N.S.	4.5	6.5	5.0	4.3
N_{90}	56.3	-	100.3	-	57.8	-
N_{120}	58.2	-	99.6	-	62.3	-
N_{150}	56.7	-	100.3	-	61.0	-
S.E$_D$.	2.62	-	2.0	-	2.23	-
C.D.(P=0.05)	N.S.	-	N.S.	-	N.S.	-
P_{18}	-	56.4	-	102.2	-	48.8
P_{22}	-	54.5	-	106.4	-	53.0
S.E$_D$.	-	1.95	-	2.9	-	2.0
C.D.(P=0.05)	-	N.S.	-	N.S.	-	N.S.
Direct sowing	64.1	62.2	104.9	109.1	49.5	44.8
20 day	-	58.5	-	106.3	-	47.1
30 day	55.3	51.2	98.3	102.1	65.1	55.0
45 day	51.8	49.8	96.2	99.0	66.5	57.0
S.E$_D$.	2.12	1.5	1.1	1.62	2.0	1.5
C.D.(P=0.05)	4.72	3.1	2.3	3.29	4.0	3.1

Note : Interactions are not significant
N.S. : Not significant

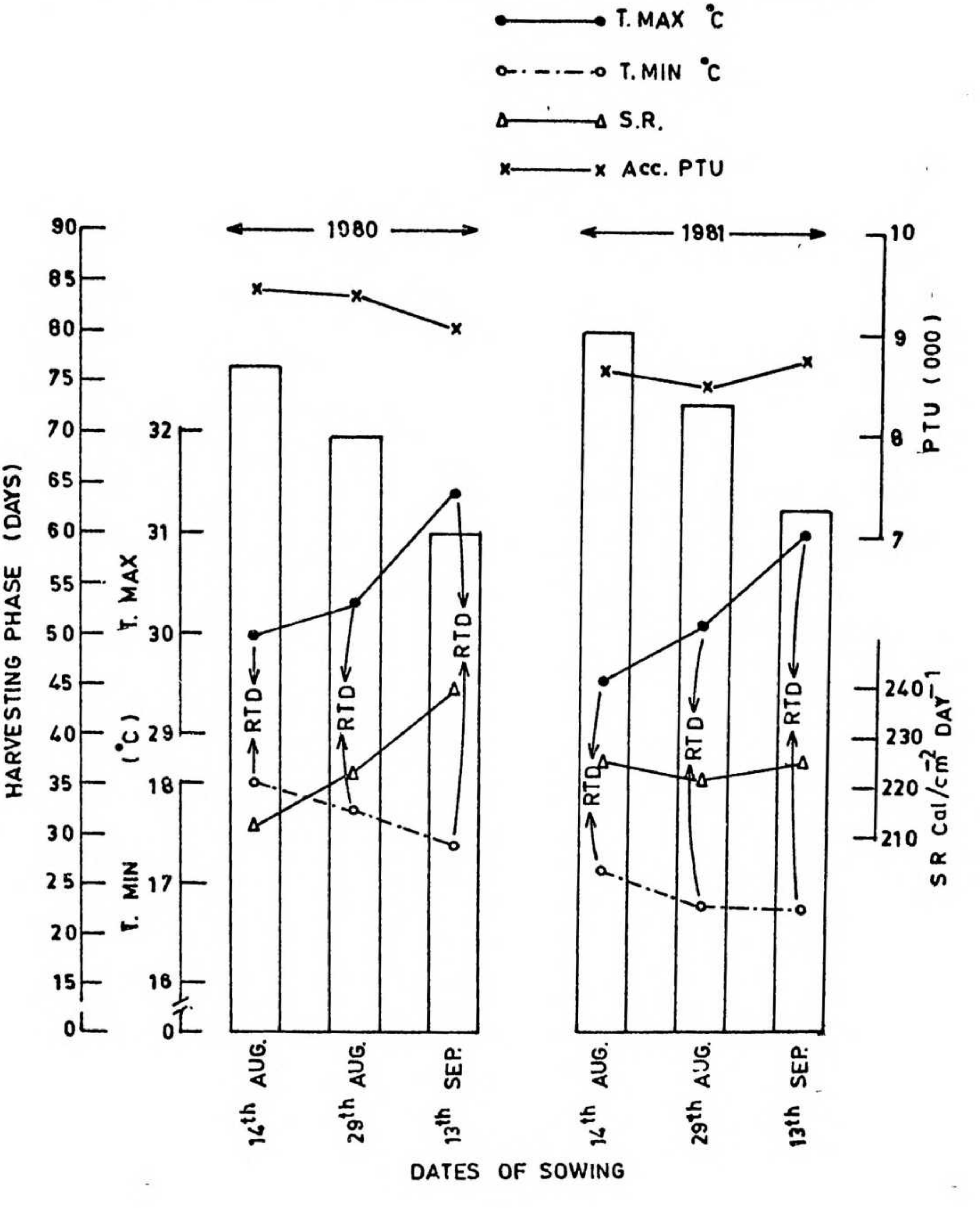
Seventy five per cent of the total duration of the direct sown crop was taken as the base period to determine the earliness of the treatments. There was a progressive increase in the per cent of seed cotton harvested to the total for the successive delay in the sowings and transplantings. The earliness in the late sown and transplanted crops could be attributed to the shortened boll maturation period. The duration of the boll maturity was influenced by the weather parameters prevailed during the harvesting periods.

A highly significant negative association (r = -0.905) existed between PTU and the duration of the harvest period. On the other hand, SR levels received did not have any effect on the duration (r = -0.201) as there were not much variations. There was a gradual increase in the day temperature from the middle of January to March which coincided with the peak harvests of the late sown crops (Fig.9). Contrary to the boll maturation period, the HTD was caused mainly by the raise of day temperature which would have hastened the maturity, resulting in early bursting of bolls. Young et al. (1980) found a very close negative relationship between the growing degree days and the harvesting periods.

The nitrogen levels had no effect on the earliness in the harvest.

The levels of population did not affect the duration of the harvesting period.

FIG.9 EFFECT OF WEATHER DURING HARVESTING PERIOD



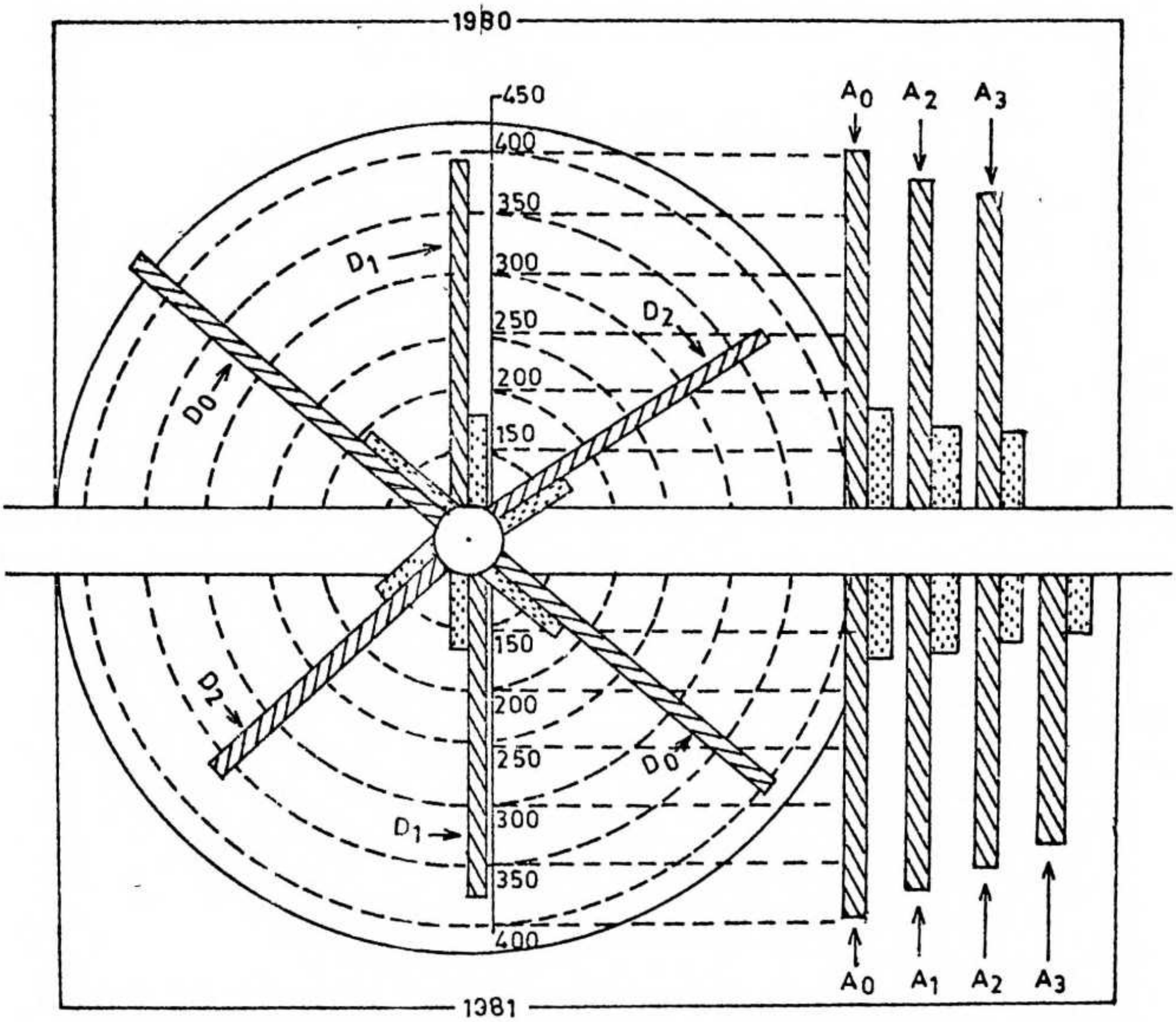
The per cent of harvested seed cotton to the total was greater in transplanted crops as compared to the direct sown ones. In both the years, the 30 and the 45 day old seedlings did not differ among themselves. In 1981, the 30 and the 45 day old seedlings recorded significantly increased values over the 20 day old seedling. Thus, transplanted crops exhibited a definite earliness over the direct seeding which was also supported by the data on the earliness in flowering, boll maturity and the total field duration.

4.19. Energy conversion efficiency (Table 20)

The quantum of solar energy available for photosynthesis during the cropping period was higher in the year 1980 than 1981. A progressive decrease in the quantum of SR received for each shift in the sowing dates (Fig. 10) was recorded.

Highest energy conversion efficiency was recorded in terms of biological as well as economic yield with the 14th August sown and transplanted crops, closely followed by the 29th August and 13th September crops. The optimum development of leaf area in the early crops might have favoured better interception of incident radiation, increasing the photosynthetic efficiency. The early sown crops had a favourable climatic conditions for higher production efficiency. Moss and Musgrve (1972) pointed out that the optimum planting dates take advantage of light and temperature regimes of nature that best fit the photosynthetic efficiency of the cultivars.

FIG.10 SOLAR ENERGY RECEIVED AND AVAILABLE FOR PHOTOSYNTHESIS



S.R RECEIVED, S.R AVAILABLE — CAL/10^{10}/ha.

AGE OF SEEDLING

A_0 DIRECT SOWING

A_1 20 DAY

A_2 30 DAY

A_3 45 DAY

DATES OF SOWING

D_0 14th AUG.

D_1 29th AUG.

D_2 13th SEP.

Table 20. Energy conversion efficiency in biological and economic yields of cotton

Treatment	Energy conversion efficiency (Per cent)			
	Biological yield		Economic yield	
	1980	1981	1980	1981
14th August	1.42	1.52	0.76	0.66
29th August	1.36	1.53	0.70	0.60
13th September	1.20	1.24	0.64	0.53
N_{90}	1.14	-	0.69	-
N_{120}	1.32	-	0.74	-
N_{150}	1.58	-	0.68	-
Direct sowing	1.45	1.52	1.45	0.55
20 day	-	1.53	-	0.65
30 day	1.48	1.59	1.48	0.76
45 day	1.30	1.58	1.30	0.67

The nitrogen levels improved the energy conversion efficiency. Interms of economic yield, highest efficiency was observed with 120 kg N/ha followed by 90 and 150 kg N/ha. Under 150 kg N/ha, the LAI was in excess of the optimum, inhibiting the normal solar energy harvesting efficiency due to mutual shading. This inturn might have resulted in nutritional imbalances, increasing the shedding of floral parts as reflected in boll number per plant. The LAI might have been sub-optimal under N_{90} to intercept the available solar energy. The role of optimum LAI for efficient harvesting of solar energy was pointed out by Constable and Gleeson (1977).

Higher population levels promoted the conversion efficiency both interms of biological and economic yields. This might be due to interception of solar radiation to a greater extent with increased number of plants per unit area.

The energy conversion efficiency of the 30 day old seedling in terms of biological yield did not differ with the direct seeded crop. On the other hand, it recorded a fairly increased per cent of harvesting efficiency in respect of economic produce. It may be interesting to note that, eventhough the crop received lesser amount of energy owing to shorter field duration, it proved superior in harvesting more of chemical energy (Fig.10). This might be due to the prevalance of optimum LAI for maximum photosynthetic efficiency and production of enough quantum of reproductive sinks for storing the chemical energy.

4.20. Nutrient uptake

4.20.1. Total N uptake at maturity (Table 21): Increased uptake of N maturity was noticed in the 14th August crops followed by the 29th August and the 13th September crops. The uptake pattern closely followed the DMP. The increase in the uptake in the early sown and transplanted crops was due to the increased dry matter production. The favourable weather condition prevailed was conducive for better growth of the plants. Comparatively higher temperature regimes prevailed during the cropping period of the early sown crops might have caused more mineralisation and availability of N to the plants. Dastur (1959) and Burban and Jackson (1973) observed increased uptake of N by the early sown crops.

Uptake of N was greater at higher levels of N application. N uptake was the highest at 150 kg N/ha as reflected in dry matter production. Similar pattern of N uptake was observed with the hybrid cotton CBS 156 by Shanmugasundaram and Sankaran (1978). Greater uptake of N was observed under higher population levels (P_{22}). This may be mainly due to more number of plants per unit area, resulting in higher DMP and N uptake.

The uptake of N was the highest with the direct seeded crop, however, it was on par with the 20 and the 30 day old seedlings. The lowest uptake was observed with the 45 day old seedling. This might be due to the reduced vegetative growth and DMP.

4.20.2. <u>Total P uptake at maturity</u> (Table 21): Total P uptake was higher in the 14th August crop, followed by 29th August and the 13th September crops. The higher uptake could be attributed to the increased vegetative growth and the high DMP.

Nitrogen application at 120 kg/ha increased the P uptake over the 150 and 90 kg N/ha. The effect of N in increasing the relative absorption of P was probably due to the increase in DMP and also to chemical interaction between N and P, stimulating root development and consequently absorption of P. Similar trend of uptake of P was reported by Aravindbabu (1980).

Higher population (P_{22}) resulted in greater uptake of P. This might be due to the increase in DMP with more number of plants per unit area. Venkitaswamy (1980) observed similar uptake pattern in MCU 9 cotton.

In both the cropping seasons, P uptake was greater in the direct sown crops, however, was on par with the 20 and the 30 day old seedlings. The lowest uptake with the 45 day old seedling was due to the lesser DMP.

4.20.3. <u>Total K uptake at maturity</u> (Table 21) : Uptake of K in the 14th August crop was higher followed by a progressive decline with the 29th August and the 13th September crops. The variations in the uptake were similar to that of N and DMP.

Table 21. Uptake of N, P and K by cotton

Treatment	N (kg/ha)		P (kg/ha)		K (kg/ha)	
	1980	1981	1980	1981	1980	1981
14th August	150	157	19	22	105	110
29th August	138	145	17	19	83	88
13th September	91	93	10	13	68	70
$S.E_{D.}$	4.2	4.8	1.0	1.2	2.3	2.1
C.D.(P=0.05)	9.3	11.0	2.3	2.8	5.3	4.6
N_{90}	105	-	13	-	76	-
N_{120}	124	-	17	-	84	-
N_{150}	142	-	16	-	96	-
$S.E_{D.}$	4.2	-	1.0	-	2.3	-
C.D.(P=0.05)	9.3	-	2.3	-	5.3	-
P_{18}	-	121	-	14	-	84
P_{22}	-	143	-	21	-	95
$S.E_{D.}$	-	4.8	-	1.2	-	2.1
C.D.(P=0.05)	-	11.0	-	2.8	-	4.6
Direct sowing	134	140	18	20	97	95
20 day	-	138	-	19	-	96
30 day	132	128	17	19	93	92
45 day	104	120	11	12	66	75
$S.E_{D.}$	2.9	2.5	0.7	0.9	2.0	1.9
C.D.(P=0.05)	5.8	5.0	1.4	1.8	4.0	3.8

Note : Interactions are not significant

The demand for K in the early sown crop was more due to the favourable weather conditions for better vegetative growth. Ravichandran (1981) reported that uptake of K was greater in the seasons when favourable conditions existed for better growth.

A progressive increase in K uptake for the N application was observed. This is in confirmity with the earlier findings (Dastur and Dabir, 1962 and Jaganathan, 1979).

Higher plant population resulted in greater uptake of K due to the increased DMP as observed in the case of N uptake.

In both the cropping seasons, the uptake of K was higher in the direct sown crop and was, however, on par with the 30 day old seedling in 1980 and the 20 and the 30 day old seedlings during 1981. The uptake was the lowest with the 45 day old seedling as observed with the uptake of N and P.

4.2.4. Economics (Table 22)

If any new technology is to be accepted by the farming community profitability should go hand with increased productivity. Therefore, economics of different treatments was worked out for the two seasons. Cost of cultivation for each treatment was worked out, taking in to account the various input costs. The net income was arrived by subtracting the cost of cultivation. Net return was divided by the cost of cultivation to get the net return per rupee invested.

The highest net return was obtained with the 14th August crop followed by the 29th August and the 13th September crops. This was because of the reduction in seed cotton yield. The net return per rupee invested was high in the 14th August crop, followed by the 29th August and the 13th September crops. The results brought out the importance of the non-monetary input, i.e. sowing the crop at the optimum period so as to make full use of the natural environment.

Application of 120 kg N/ha resulted in the highest net return and return per rupee invested. This was due to the increased yield of seed cotton obtained over the levels of 150 and 90 kg N/ha.

The higher population level (P_{22}) gave a higher net return and return per rupee invested than the lower level (P_{18}).

In both the cropping seasons, the transplanted crop with the 30 day old seedling resulted in higher net return and return per rupee invested than the direct seeded crop as well as the 45 day old seedling. This was closely followed by the 20 day old seedling in 1981. Thus, transplanting with the 30 day old seedling proved to be more economical with higher net returns than the conventional direct seeding owing to higher yield and reduced cost of cultivation.

Table 22. Net return in cotton (Rs/ha)

Treatment	Net return (Rs)		Net return per rupee invested (Rs)	
	1980	1981	1980	1981
14th August	13,589	12,395	2.03	1.85
29th August	10,476	8,441	1.53	1.26
13th September	8,584	6,899	1.28	1.05
S.E$_{D}$.	450	495	0.11	0.06
C.D.(P=0.05)	1,035	1,139	0.25	0.15
N_{90}	10,691	-	1.63	-
N_{120}	11,787	-	1.74	-
N_{150}	10,257	-	1.51	-
S.E$_{D}$.	450	-	0.11	-
C.D.(P=0.05)	1,035	-	0.25	-
P_{18}	-	8,363	-	1.25
P_{22}	-	10,511	-	1.57
S.E$_{D}$.	-	495	-	0.06
C.D.(P=0.05)	-	1,139	-	0.15
Direct sowing	9,972	7,955	1.47	1.17
20 day	-	9,731	-	1.46
30 day	12,691	11,405	1.89	1.71
45 day	9,977	8,495	1.50	1.28
S.E$_{D}$.	398	415	0.08	0.04
C.D.(P=0.05)	7.96	830	0.16	0.08

Prices assumed: Seed cotton .. Rs.6.00/kg
N .. Rs.4.50/kg
P .. Rs.5.00/kg
K .. Rs.1.60/kg

Note: Interactions are not significant

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

Field experiments were conducted in the experimental farm of the Tamil Nadu Agricultural University, Coimbatore from 1979 to '81 to explore the possibility of transplanting cotton. Two cultivars (Varalakshmi and MCU 9), two methods of nursery practices (_Pai_ nursery and polythene bag) coupled with three ages of seedling (20, 40 and 60 days) were compared with direct sowing in a randomised blocks design during 1979.

Based on the results of the first year experimentation, treatments were modified during the subsequent years. During 1980, two ages of seedlings (30 and 45 day) along with direct seeding were compared under three dates (14th August, 29th August and 13th September) at three levels of N application (90, 120 and 150 kg/ha), while, three ages of seedling (20, 30 and 45 day) with one direct seeding were studied under three dates during 1981. Two population levels (17,860 and 22,222 plants/ha) were included in the place of nitrogen levels. The experiments were tried in a split plot design.

Observations on the climatic parameters, growth components, yield components, yield, quality characters and nutrient uptake were recorded. A brief summary of the results obtained and the conclusions drawn are presented below.

The mean maximum and minimum temperatures prevailed during the cropping periods were 29.1 and 19.8 in 1979, 30.9 and 19.8 during 1980, 29.9 and 19.2 °C in 1981, respectively, as against the 30 years average of 30.0 and 21.1 °C. Maximum temperature did not deviate from the normal, while a slight reduction in the minimum temperature was observed. The derived meteorological parameters such as accumulated PTU and SR levels showed a slight variation between 1980 and 1981 seasons. The accumulated PTU during the cropping period of 1980 and 1981, respectively, were 29,750 and 27,824 and the SR values were 43,110 and 41,697 Cal cm^{-2}. Rainfall during the crop period was 955 mm in 29 rainy days in 1979, 484 mm in 19 rainy days in 1980, and 243 mm in 27 rainy days in 1981 as against the 30 years average of 443 mm in 30 rainy days. The amount of rainfall during the 1979 cropping season was abnormal. The continuous rainfall during the month of November rendered plant protection measures difficult. Besides, the cloudy weather with reduced solar radiation levels favoured shedding which brought down the general yield level during 1979.

Among the cultivars, the hybrid, Varlakshmi was found to be superior in respect of growth characters, yield components and yield potential to the variety MCU 9.

The two nursery methods viz., Pai nursery and polythene bag did not exhibit any differential influence on growth characters, yield components and yield. On the basis of economics, easiness in raising and maintenance, pai nursery offered scope for large scale adoption. The extent of establishment of seedlings in the main field ranged from 92-98 per cent while, the germination was only 86-92 in the direct seeded crop.

The crops sown and transplanted on 14th August were taller, had larger LAI and DMP. The number of monopodia, sympodia, fruiting points and boll number were greater as compared to the 29th August and the 13th September crops due to the reduction in PTU and SR levels prevailed during the respective cropping periods. The SR levels had a significant influence on growth components. The SR levels received was low due to the cloudy monsonic weather during the months from October to December, resulting in low boll number in the late sown crops.

A reduction in seed cotton yield to the tune of 9 q/ha was observed with the 13th September crops as compared to the 14th August crop. About 74 per cent of the total variation in seed cotton yield could be attributed to the quantum of SR received during the cropping periods as brought out by the significant positive regression coefficient. For getting about 30 q/ha of seed cotton, an accumulated PTU of 27,000 (2,500 growing degree days) and a SR level of 40,000 cal cm^{-2} (222 cal $cm^{-2} day^{-1}$) would be required.

The date of sowings had no influence on the quality characters, like ginning per cent, lint index, seed index, maturity coefficient, fibre fineness and bundle strength, except the fibre length which was superior in the early crop.

The boll maturation period was longer with the 14th August crop. The shorter boll maturation period with late sown crops might have been due to a drop in the night temperature, increasing the RTD during the months of December and January. There was a significant positive correlation between boll maturation period, PTU and SR levels. The total field duration of the crop sown on 13th September got reduced by 15 days due to a shortened harvesting period. There was a diminished accumulation of PTU and SR values with the late sown crops.

The solar energy conversion efficiency was high with 14th August sown and transplanted crops due to a larger LAI and higher DMP. The uptake of the major nutrients was greater with the early crops, owing to a better vegetative growth and and increased DMP.

Application of N at 120 kg/ha favourably influenced the number of fruiting points, boll number, boll set and seed cotton yield. An interaction effect between the N levels and the dates of sowings was observed. Application of 120 kg N/ha was economical for the 14th August crops, while 90 kg N/ha was more economical for the 29th August and the 13th September crops. The levels of N had no effect on quality characters except the seed index. Nitrogen application promoted the solar energy conversion efficiency by increasing the DMP. The uptake of P and K increased with the enhanced application of N.

Plant height, LAI and DMP were increased at higher population density. The yield components of the individual plants were higher under lower population. The higher population level resulted in enhanced seed cotton yield because of increased number of plants per unit area. However, an interaction effect with dates of sowing indicated that the population levels were of no consequence with the 14th August crop, while, the higher level markedly increased the yield under late sown conditions. None of the quality characters was affected by the population levels. Solar energy conversion efficiency was greater with higher population. The uptake of N, P and K was more with the higher population.

The transplanted crops were shorter than the direct sown ones. Similar trend of reduced LAI and DMP was also observed. Higher number of bolls due to greater boll set was observed with the 30 day old seedling.

In 1979, the 20 day old seedling produced higher seed cotton than that from the 40 and 60 day old seedlings and as much as 97 per cent of the direct sown crops. During 1980 and 81, the 30 day old seedling excelled the respective direct sown crops in seed cotton yield. During 1981, the 20 day old seedling was distinctly superior to the direct sowing and the 45 day old seedling. The increase in seed cotton yield with the 30 day old seedling was more pronounced particularly under late transplanted conditions as against its respective direct seeded crops. The seed cotton yield from the 30 day old seedling transplanted on 29th August was comparable with that from the direct seeded crops sown on 14th August. Similarly the 30 day old seedling transplanted on 13th September resulted in enhanced seed cotton yield over the 29th August direct seeding.

The use of 30 day old seedling could bring in a reduction of two weeks in field duration as compared to the direct seeded crop. The solar energy conversion efficiency in respect of economic yield was greater with the 30 day old seedling as against the direct sown crops. The transplanted crops did not differ in quality characters with the direct seeded crops. The mean fibre length was even greater with the 20 and the 30 day old seedlings than in the direct seeding. The uptake of N, P and K with the 30 day old seedling was almost equal to that of direct seeding and was superior to the 45 day old seedlings.

From the results of the present study it may be concluded that the hybrid, Varalakshmi is preferable to MCU 9 in respect of yield. Raising seedlings through pai nursery is economical and easier for adoption in large scale by the farmers. By resorting to transplanting, it is possible to achieve a high plant stand in the main field. Gap filling can be done on the 4th day itself after transplanting with the seedlings from the same nursery. The optimum age of seedling for transplanting is 30 days.

The major constraints in sowing the cotton at the optimum period in the season are the belated harvest of the previous crops, delayed availability of water in the canals for irrigation and low water levels in the wells. Under such conditions, transplanting would be a viable technology to tide over the situation. Pai nurseries can be raised in advance depending upon the anticipated delay and the seedlings transplanted as soon the field is ready. Transplanting could be done over a period of one month beyond the normal sowing date. The yield advantage would be greater with the crops transplanted late in the season as compared to a direct seeded crop sown even a fortnight prior to transplanting. The farm water budget can be regulated by having staggered transplantings of seedling according to the availability of water.

Field duration is of great consequence in the adoption of multiple cropping systems. Transplanting the 30 day old seedling offers ample scope in reducing the field duration by about two weeks. The net return with the 30 day old seedling would be more due to increased yield and reduced cost of cultivation.

The other agronomic practice that complements the transplanting in compensating the yield losses under late sown conditions is the enhancement of population density. Transplanting the 30 day old seedling with a population of 22,222 plants/ha during the first fortnight of September would increase the yield by about 5 q/ha over the normal population of 17,860 plants/ha. For the crops transplanted late during the first fortnight of September a lesser dose of 90 kg N/ha is more economical over the recommended dose of 120 kg N/ha. Thus, transplanting proves to be a sound agronomic practice in compensating the probable yield loss due to late direct seeding.

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(N.GOPALASWAMY)

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* Originals not seen

Appendices

APPENDIX I

Weather data for the cropping period (1979-82)

Number	Standard week		Rainfall (mm)	Temperature (°C)		Relative humidity(%)		Solar radiation cal cm^{-2} day^{-1}
				Maxi-mum	Mini-mum	0722 hrs.	1422 hrs.	
1979								
32	Aug.	6-12	19.7	29.5	22.2	77	59	235.4
33		13-19	-	32.6	21.1	81	49	254.8
34		20-26	0.8	32.1	21.5	90	49	250.4
35	Sep.	27- 2	1.0	32.2	21.7	91	49	228.7
36		3- 9	4.3	32.2	22.0	89	56	178.1
37		10-16	28.6	32.1	22.1	92	57	198.5
38		17-23	68.4	28.9	21.9	93	72	188.4
39		24-30	-	30.7	22.1	81	54	231.0
40	Oct.	1- 7	19.8	32.5	20.9	88	50	239.4
41		8-14	46.2	30.9	22.3	94	59	178.4
42		15-21	3.4	31.2	20.5	87	43	213.3
43		22-28	88.3	29.3	21.3	93	70	188.1
44	Nov.	29- 4	56.4	29.6	21.0	95	60	254.3
45		5-11	21.7	27.7	21.3	94	75	179.0
46		12-18	283.0	27.3	21.2	96	84	172.3
47		19-25	293.6	27.4	21.6	94	75	217.0
48	Dec.	26- 2	15.2	28.3	21.6	94	65	201.8
49		3- 9	0.7	28.2	20.0	93	61	252.4
50		10-16	3.7	28.2	20.8	91	60	220.8
51		17-23	-	29.5	19.1	91	45	226.7
52		24-31	0.4	28.5	17.2	90	49	251.0
1980								
1	Jan.	1- 7	-	29.4	16.6	85	43	252.8
2		8-14	-	30.0	15.7	89	37	257.2
3		15-21	-	29.1	17.4	85	38	250.0
4		22-28	-	30.0	14.7	85	30	251.2

(Continued)

APPENDIX I (Continued)

Number	Standard week	Rain-fall (mm)	Temperature (°C)		Relative humidity(%)		Solar radiation Cal cm^{-2} day^{-1}
			Maxi-mum	Mini-mum	0722 hrs.	1422 hrs.	
5	Feb. 29- 4	-	30.8	17.1	81	38	232.6
6	5-11	-	31.6	17.9	85	32	246.0
7	12-18	-	32.0	16.8	83	29	251.3
8	19-25	-	33.3	16.5	81	23	272.3
9	Mar. 26- 4	-	34.7	19.1	84	28	265.2
10	5-11	-	34.9	19.3	84	33	253.1
1980							
32	Aug. 6-12	-	31.7	21.4	70	50	204.3
33	13-19	14.1	30.3	22.3	82	58	277.7
34	20-26	1.6	31.0	22.3	76	53	222.5
35	Sep. 27- 2	-	31.8	22.1	75	47	224.0
36	3- 9	-	31.3	22.3	81	56	195.1
37	10-16	-	32.6	20.6	88	46	246.2
38	17-23	60.3	32.7	20.8	91	47	245.2
39	24-30	11.2	31.2	22.1	92	58	203.3
40	Oct. 1- 7	-	31.7	22.3	88	55	218.0
41	8-14	47.1	30.7	21.5	92	68	214.2
42	15-21	161.3	30.5	21.5	91	63	204.0
43	22-28	1.2	30.3	21.4	91	62	263.7
44	Nov. 29- 4	7.2	31.2	19.1	85	38	249.6
45	5-11	46.3	30.6	19.8	90	45	212.2
46	12-18	141.9	28.0	21.6	95	75	280.4
47	19-25	3.7	28.7	20.3	91	56	201.9
48	Dec. 26- 2	0.8	30.5	18.5	87	52	136.7
49	3- 9	5.6	29.8	19.7	88	52	208.6
50	10-16	-	30.5	19.6	83	45	217.3
51	17-23	1.2	29.3	18.4	86	55	165.3
52	24-31	-	29.6	19.1	90	50	179.6

(Continued)

APPENDIX I (Continued)

Number	Standard week	Rain-fall (mm)	Temperature (°C) Maxi-mum	Mini-mum	Relative humidity(%) 0722 hrs.	1422 hrs.	Solar radiation Cal cm^{-2} day^{-1}
1981							
1	Jan. 1- 7	-	30.1	18.3	83	42	220.0
2	8-14	-	30.8	17.3	90	40	241.6
3	15-21	-	28.7	18.9	82	50	192.0
4	22-28	-	30.6	18.4	88	48	242.0
5	Feb. 29- 4	-	31.9	15.4	87	38	251.3
6	5-11	-	32.0	18.9	85	38	244.0
7	12-18	-	32.1	18.2	77	36	252.0
8	19-25	-	32.2	15.4	73	25	263.0
9	Mar. 26- 4	-	33.8	15.9	77	17	273.5
10	5-11	-	33.9	20.1	86	30	257.2
32	Aug. 6-12	4.0	30.2	22.8	74	62	232.5
33	13-19	5.7	30.6	22.7	80	63	202.5
34	20-26	6.6	31.8	21.6	85	55	217.7
35	Sep. 27- 2	19.0	30.0	21.7	92	73	146.5
36	3- 9	11.6	31.4	21.6	90	52	221.5
37	10-16	75.4	29.5	21.4	96	71	180.4
38	17-23	31.0	29.6	21.8	85	70	192.2
39	24-30	-	31.7	21.4	81	48	240.5
40	Oct. 1- 7	16.4	31.3	20.3	85	52	209.6
41	8-14	59.2	29.8	21.4	93	64	171.8
42	15-21	74.1	29.3	21.6	91	65	157.1
43	22-28	29.2	28.2	19.9	94	95	137.6
44	Nov. 29- 4	60.9	29.3	20.5	91	73	175.1
45	5-11	23.8	30.0	21.5	95	74	181.0
46	12-18	-	29.9	20.3	89	56	213.9
47	19-25	-	30.1	17.5	88	47	245.3
48	Dec. 26- 2	20.0	28.0	19.4	90	76	144.6
49	3- 9	20.0	28.7	17.2	92	67	216.4
50	10-16	0.2	29.0	15.2	93	58	226.4

(Continued)

APPENDIX I (Continued)

Number	Standard week	Rainfall (mm)	Temperature (°C) Maximum	Temperature (°C) Minimum	Relative humidity (%) 0722 hrs.	Relative humidity (%) 1422 hrs.	Solar radiation Cal cm^{-2} day^{-1}
51	Dec. 17–23	13.2	27.3	19.6	94	74	137.6
52	24–31	–	28.4	16.0	96	64	230.9
1982							
1	Jan. 1– 7	–	28.2	16.7	93	49	224.5
2	8–14	–	28.6	17.8	89	48	225.3
3	15–21	–	29.7	16.2	92	44	252.0
4	22–28	–	29.2	17.2	91	40	219.3
5	Feb. 29– 4	–	30.1	16.7	89	42	237.2
6	5–11	–	31.9	18.4	82	32	280.0
7	12–18	–	33.2	15.3	79	27	266.8
8	19–25	–	33.3	17.6	85	27	274.2
9	Mar. 26– 4	–	34.0	17.8	79	26	278.0
10	5–11	–	35.2	20.6	82	33	270.0

Total 4703 902.3 579.1 2747 1694

mean 30.08 19.30 91.56 56.46

APPENDIX I (Continued)

Mean of 30 years (1951 - 1980)

Months	Rainfall (mm)		Temperature °C		Relative humidity (%)		Hours of bright sunshine
	Total	Rainy days	Maxi-mum	Mini-mum	0722 hrs.	1422 hrs.	
January	6.0	0.59	29.0	17.8	87.5	46.5	8.7
February	6.8	0.49	31.5	18.3	84.2	41.0	9.3
March	16.7	0.69	34.3	20.1	81.8	34.0	10.0
April	29.1	2.1	35.1	23.0	84.0	55.2	8.9
May	68.0	3.0	34.0	23.1	71.6	48.5	6.6
June	40.8	2.8	31.8	23.0	78.8	55.8	9.7
July	54.9	3.0	30.1	22.3	83.2	58.7	4.3
August	34.6	3.0	30.7	22.4	82.8	57.2	7.1
September	46.7	4.5	31.3	21.8	85.5	55.5	7.1
October	164.0	9.2	30.8	21.3	91.0	60.0	6.3
November	160.1	9.6	29.3	20.5	91.0	57.0	6.6
December	24.8	2.7	27.1	18.7	90.0	57.2	11.5

APPENDIX II

Duration of day length
(Latitude 11°N)

Days of month	January h. m.	February h. m.	March h. m.	April h. m.	May h. m.	June h. m.	July h. m.	August h. m.	September h. m.	October h. m.	November h. m.	December h. m.
10	11.30	11.43	12.01	12.21	12.37	12.46	12.46	12.30	12.14	12.01	11.41	11.32
20	11.34	11.48	12.07	12.25	12.41	12.46	12.39	12.22	12.12	11.51	11.38	11.31
30	11.37	11.54	12.33	12.31	12.45	12.47	12.34	12.19	12.01	11.47	11.34	11.30

Duration of day length at 5 days interval (at 11°N latitude) workedout in hours (1 minute = 0.017 hrs.)

Days of month	January	February	March	April	May	June	July	August	September	October	November	December
1	11.500	11.629	11.918	12.221	12.527	12.765	12.799	12.578	12.323	12.017	11.799	11.578
5	11.500	11.680	11.977	12.289	12.578	12.773	12.790	12.544	12.280	12.017	11.748	11.561
10	11.500	11.731	12.017	12.307	12.629	12.782	12.782	12.500	12.238	11.017	11.697	11.544
15	11.544	11.773	12.068	12.391	12.663	12.782	12.722	12.442	12.221	11.952	11.671	11.535
20	11.578	11.816	12.119	12.425	12.697	12.782	12.663	12.374	12.204	11.867	11.646	11.527
25	11.603	11.867	12.170	12.476	12.731	12.790	12.620	12.348	12.110	11.833	11.612	11.518
30	11.629	11.918	12.221	12.527	12.765	12.799	12.578	12.323	12.017	11.799	11.578	11.500

(Source : Monthly dew register and summaries. c.f. Casella & Co., Ltd., London)

APPENDIX III

Accumulated photothermal units

Date of sowing	Ages of seedlings	Sowing to flowering	Sowing to open boll	Sowing to harvest	Flowering to boll open	Flowering to harvest	Open boll to harvest
1980							
14th Aug.	Direct sowing	12,094	19,261	29,750	8,193	17,656	9,463
	30 day	10,397	18,323	26,825	8,840	16,428	7,558
	45 day	9,057	17,141	24,958	8,967	15,901	6,934
29th Aug.	Direct sowing	11,118	17,223	27,607	7,009	16,419	9,410
	30 day	10,239	16,065	25,716	6,757	15,477	8,720
	45 day	10,192	15,997	25,213	7,042	15,021	7,979
13th Sep.	Direct sowing	10,497	16,010	26,030	6,638	15,533	8,895
	30 day	9,869	15,967	24,801	6,739	14,932	8,193
	45 day	10,195	16,231	23,923	7,070	13,728	7,691
1981							
14th Aug.	Direct sowing	11,494	18,256	27,824	7,618	16,330	8,712
	20 day	10,790	17,642	27,590	7,773	16,800	9,027
	30 day	8,440	15,796	25,204	8,368	16,764	8,396
	45 day	8,044	15,278	24,358	8,297	16,314	8,017
29th Aug.	Direct sowing	10,765	15,796	25,163	6,951	14,398	8,467
	20 day	10,186	15,441	24,139	6,114	13,953	7,839
	30 day	8,979	14,723	23,126	6,678	14,147	7,469
	45 day	9,718	15,331	23,030	6,680	13,312	6,632
13th Sep.	Direct sowing	9,397	14,736	24,342	6,092	14,945	8,853
	20 day	8,784	14,506	23,422	6,590	14,635	8,048
	30 day	7,925	13,813	22,749	6,962	14,522	7,860
	45 day	7,481	13,415	21,416	6,917	13,935	6,529

APPENDIX III (Continued)

Accumulated solar radiation cal cm^{-2}

Dates of sowing and transplanting	Age of seedling	Sowing to flowering	Sowing to Open boll	Sowing to harvest	Flowering to open boll	Flowering to harvest	Open boll to harvest
1980							
14th Aug.	Direct sowing	14,846	25,690	43,110	12,511	28,264	15,753
	30 day	12,547	21,441	39,536	13,504	26,989	15,395
	45 day	11,318	23,563	38,316	13,743	26,998	13,255
29th Aug.	Direct sowing	13,545	22,530	40,106	10,485	26,561	16,075
	30 day	14,085	22,911	38,043	10,324	23,958	13,634
	45 day	13,568	22,893	37,356	10,833	23,288	12,965
13th Sep.	Direct sowing	13,387	21,821	38,780	9.930	25,393	15,463
	30 day	13,631	21,393	36,120	9,223	22,489	13,266
	45 day	13,652	21,023	35,030	8,869	21,378	12,509
1981							
14th Aug.	Direct sowing	13,635	22,831	41,697	10,698	28,062	17,364
	20 day	12,307	20,953	39,742	9,944	27,235	17,372
	30 day	10,079	18,715	37,314	10,132	26,920	17,103
	45 day	8,966	17,261	35,258	10,132	26,920	16,502
29th Aug.	Direct sowing	11,574	19,742	38,392	9,661	25,177	17,157
	20 day	11,272	19,501	36,449	9,717	24,565	15,460
	30 day	9,731	17,703	34,296	9,464	23,048	15,101
	45 day	9,884	17,756	32,932	9,364	28,014	13,684
13th Sep.	Direct sowing	9,823	18,553	37,837	10,222	26,736	17,792
	20 day	9,750	18,723	36,486	10,474	26,731	16,262
	30 day	8,684	18,147	35,415	10,952	27,802	15,779
	45 day	8,669	18,141	33,473	10,968	24,804	13,836